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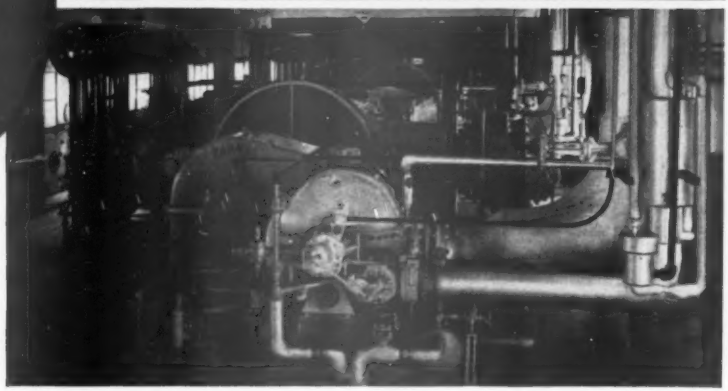

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On the Cover — Native workmen weld a section of six-inch pipe under a tropical Indonesian sun near Minas camp. Labor is only one factor in the problems that oil companies must deal with in foreign production operations. A comprehensive view of the free world's supply situation is given in the article beginning on page 15. . . . *Photo courtesy Caltex Pacific.*

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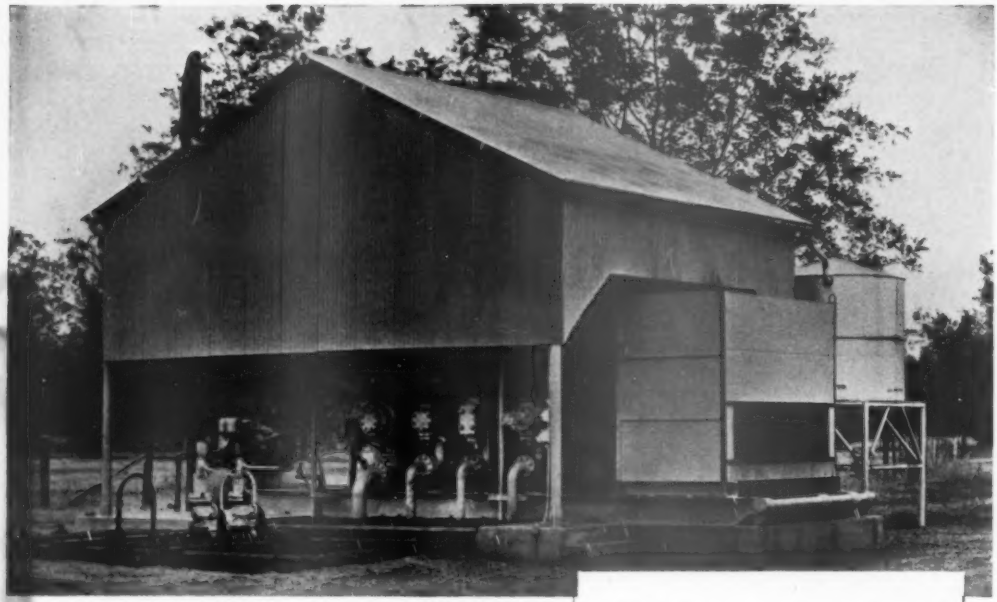

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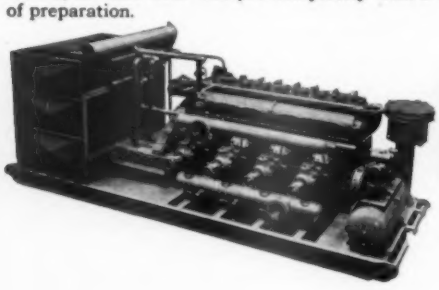

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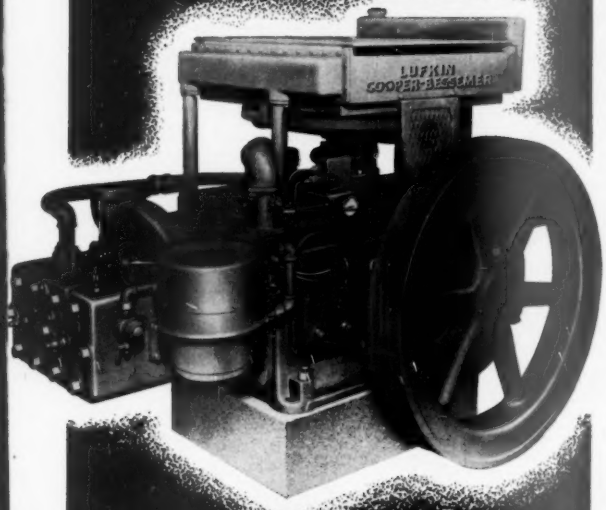

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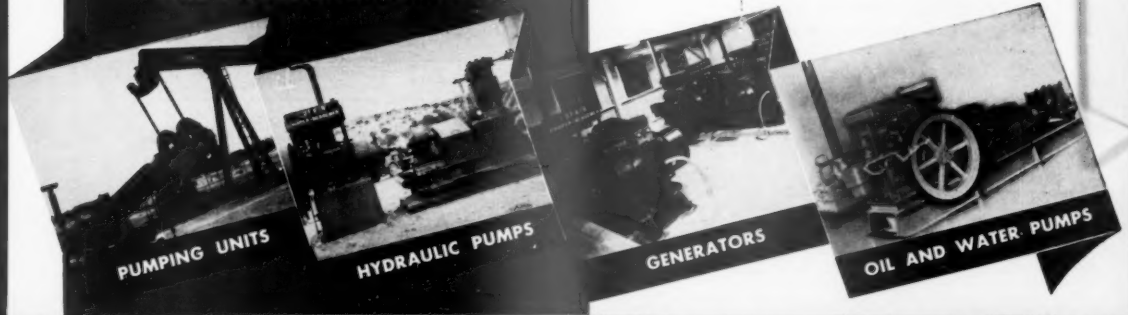

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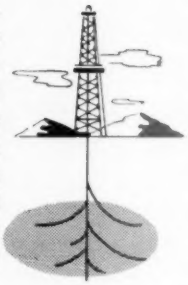

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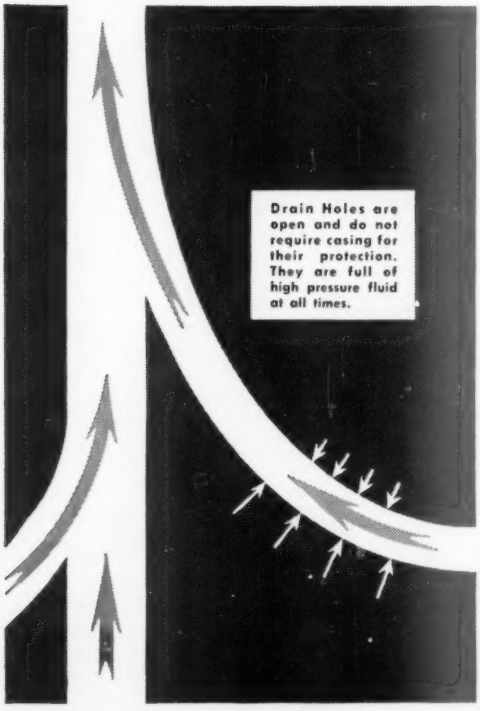

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Inside Deposits sand up the well or its pumping equipment which then requires frequent pulling jobs and replacements with the corresponding loss of production, time and money.

3. Improper Water Drive produces excess water due to coning around the well. Bottom water, with less resistance to flow than oil, fills the depleted sand around the well, which then produces water instead of oil.

4. High Gas-Oil Ratios are created when the gas in solution rapidly becomes *free gas* due to agitation of the oil during its high speed–turbulent flow. This gas, by-passing the oil, reaches the well first, leaving the oil behind.

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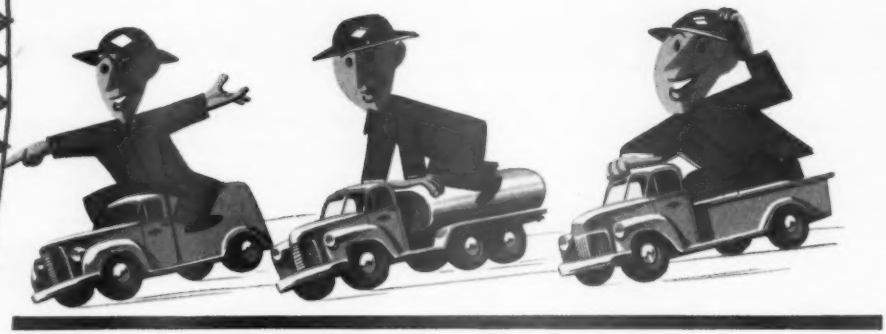

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MILITARY PETROLEUM DEMAND on the West Coast in 1951 shot up from 65,000 to 110,000 B/D. The increase was supplied largely out of surplus inventories, but now the tanks are empty.

Oil Supply and Demand on the West Coast

By Robert L. Minckler
President, General Petroleum Corp.
Member AIME

In considering "Oil Supply and Demand in the West," it is necessary to keep in mind the importance of oil in the economy of our area. In the nation as a whole, the products of our industry — oil and natural gas — provide about 56 per cent of the energy used by the people. In the western states, more than 90 per cent of the energy used comes from oil and gas. In other parts of the country, industrial and commercial plants using large volumes of oil can be converted to use coal without severe economic penalty, but that is not the case here because the West does not have cheap coal supplies. It is true that the continued growth of industrial activity in the West is dependent upon adequate supplies of oil and natural gas.

The past history of the California oil business has been one of chronic surplus, except during war times. These surpluses flowed out past our economic market limits and into markets in which we had no economic right to be.

We are now at a point where this situation will no longer prevail. We are in the process of changing from an economy of surplus to one of balance and then to one of shortage.

This change is due to two principal causes. Despite an aggressive exploration program in California, the industry has failed to find enough important new oil fields to improve our reserve position. The demand for oil products has increased at a rapid rate.

Prospects for new supplies and our demand outlook will be discussed below.

However, a view of the current, short-term situation may lead to wrong conclusions concerning the long-range position.

Currently, we are short of all classes of products. Our inventories of crude oil and products are 81 million bbl, which is a very low level, representing only 73 days' overall supply. Total demand during 1951 and for the first quarter of 1952 has been running about 35,000 B/D in excess of current supply.

This current situation is due to the Korean war and to the loss of supply from Iran.

Prior to the Korean conflict, the military demand in this area was 65,000 to 70,000 B/D. Last year (1951) this demand averaged 110,000 B/D. So long as inventories on the Pacific Coast were in excess of working levels, it was perhaps correct procedure to supply military needs from them, but now that the surplus is all gone, the supply of military products must be viewed as a national problem, not as a West Coast problem.

The California district can not be expected indefinitely to supply one-half of the military requirements with only one-sixth of the crude oil production of the country, as it has been called upon to do. The governmental agencies in Washington and the industry east of the Rockies should consider this problem and shift some of the direct military demands to other shoulders able to bear them.

We have felt the impact of the Korean war and the accelerated defense program in areas other than direct military requirements. For example, prior to June, 1950, heavy fuel oil requirements of our railroads were about 55,000 B/D, and they were declining as the railroads replaced their steam locomotives with diesel engines. The military and industrial activity during the early phase of the Korean war, when men

and supplies were being rushed to the combat area, required the re-employment of many laid-up steam engines, and railroad heavy fuel oil demand here rose to over 70,000 B/D. However, as additional diesel units became available, and military movements of men and supplies changed to a replacement and maintenance basis, railroad usage resumed its previously established pattern of decline in heavy fuel usage as diesel oil usage increased.

Another important increase in demand has been in the use of heavy fuel oil for ships' bunkers. This is running at almost 25,000 B/D more than the pre-Korean level. This large increase is partially the result of the Korean war, which has brought a considerable number of merchant vessels out of the mothball fleet; and partially due to the fact that fuel oil bunker prices on the Pacific Coast have been very much lower than at any other place in the world. We do not know if the present high level of Pacific Ocean shipping will be maintained, but it is a reasonable expectation that the price differential which has favored West Coast bunkering of vessels will, in time, be eliminated, and some bunker business will be shifted to East Coast, Gulf Coast, and Panama Canal ports.

A new demand was placed on California oil when the Iranian oil fields and the Abadan refinery were closed down in 1951. At that time there was an immediate demand upon the West Coast petroleum industry to supply some of the foreign markets which had previously depended directly or indirectly upon Iranian oil. This new demand on California during the second half of 1951 amounted to approximately 51,000 B/D. During 1952 these added California exports should gradually be eliminated as worldwide supply and demand is again restored to an economic balance.

From the foregoing, it is clear that the currently acute oil supply situation in the West is due largely to what are, hopefully, temporary causes — the Korean war and the loss of Iran as a source of supply. The effect of these events upon California oil demand can not be calculated exactly, but it is probably on the order of 140,000 B/D. About 35,000 B/D of this extra demand came from inventories, about 20,000 B/D from unusual imports, and 85,000 B/D from current supply.

Present Production Adequate for Civilian Needs

Let us look at it in another way. The estimated civilian and industrial demand in our natural market area will be about 915,000 B/D for the next few years. About 135,000 B/D of the supply required to meet that demand will come from condensates, natural gasoline, liquefied petroleum gas, and from imports; so the California crude oil requirement from our local civilian markets is only about 780,000 B/D. With crude oil production of about 980,000 B/D at the present time, it is evident that the local civilian market can be met from our own production for several years, even without any important discoveries.

Of course, there are still the military and offshore markets to be supplied.

As above stated, military demand, pre-Korea, was running at 65,000 to 70,000 B/D. With the continuing rate of military activity which now seems unavoidable, a new normal level of military requirements — even assuming no shooting war — will probably be perhaps 50 per cent higher, or say 100,000 B/D.

As to offshore shipments, about 65,000 B/D now move to areas where California has a transportation advantage over competitive sources of supply, but that figure includes about 40,000 B/D to British Columbia, a market which will be lost as soon as the pipe line from Alberta to Vancouver is completed in 1954.

So, what we might consider the normal demands in California's natural market area, say in 1954, will be as follows:

Domestic civilian demand	915,000 B/D
Military demand	100,000 B/D
Offshore demand	25,000 B/D
Total demand	1,040,000 B/D
Less:	
Supplied from other raw materials and sources outside California	135,000 B/D
California crude oil requirement	905,000 B/D

It seems apparent that the present productive capacity of California oil wells is some 75,000 to 85,000 B/D in excess of normal demand in natural markets. This is not very much fat, but it certainly does not indicate an immediately critical short condition.

On the other hand, we will certainly not be bothered with surplus products for the next two or three years. We will still have the Canadian market to supply and we should build up more inventories. Any production in excess of normal demand in natural markets will be used for abnormal military demand and in unnatural markets, until the world comes to its senses and settles down.

There should be, then, a period of two or three years of balance between local supply and demand. This will not be exactly true at any particular time, because emergency military demands, variations in the timing of completion of oil and gas lines, volume of rainfall, fluctuation in general business conditions or any one of a number of variables can throw the figures one way or the other. In a broad, general way, however, we will be in balance — no surplus and no shortage.

From 1955 on, there are conflicting trends of future demands. To increase demand, we foresee a steadily increasing population, with more motor vehicles to fuel with gasoline, more homes to heat with burning oils, and more steam-electric generating equipment using heavy fuel oil. To decrease demand, we foresee the continued conversion of railroad locomotives from steam to diesel, the loss of some ship bunkering business, and the construction of new natural gas lines, bringing in gas which will displace some fuel oil used in industry and which will retard the rate of growth in oil home-heating.

A reasonable guess is that these conflicting demand trends will about offset each other for a few years, and that the question as to supply and demand in the West comes down to whether California can continue to produce crude oil at the current rate for the next several years.

We are currently producing 975,000 to 980,000 B/D, which is close to our production capacity at this time. We have had a very low development drilling rate for about three years, principally because of the temporary over-supply of oil in 1948 and 1949. In 1948 we completed 2,150 producing oil wells; in 1949, 1,777; in 1950 only 1,264; and in 1951, 1,719. We now have a pretty small inventory of highgrade undrilled proved locations, and even an accelerated development drilling campaign to the level of 1948 would not run our efficient production capacity to over one million B/D. At that rate, the quality of our remaining undrilled locations would be of a very low order, and their drilling would not offset natural decline. Then we would become dependent upon presently undiscovered reserves to maintain productive capacity.

The record of discoveries in California in the past few years is not encouraging. The only first class oil field found during the past ten years is Cuyama, and even Cuyama looks small when measured against a demand of 1,000,000 B/D.

Probably there are a few more Cuyamas lying around somewhere in California and many more small fields will, of course, be found; but the present prospect is that the finding costs will be high and the rewards small.

Two important production possibilities, the Elk Hills Naval Reserve and the undoubtedly large discovery possibilities offshore, have not been considered in this analysis.

We all know the political impossibility of counting the Naval Reserve as a source of potential supply. The soundest prophesy for that oil is that it will still be there after a new source of energy has displaced oil, thus continuing its so far unbroken record of complete uselessness.

In somewhat the same position is oil in the submerged lands offshore. There is, no doubt, a very large volume of oil waiting to be discovered in structures offshore from California. With the federal government's seizure of these submerged lands, they have become a political issue, and for a long time will be a source of political trading and speech making, instead of a source of energy for the use of the people. These potential reserves cannot be counted into our assets until the political picture changes. Even then, oil from the submerged lands will be expensive and will become available at slow rates.

Eventual Crude Production Shortage Foreseen

Apparently, then, we have enough oil in California for a very few years more, but we are approaching finally the day when there will be a shortage of overall local crude oil production, probably in 1955.

This does not mean that there will be an oil shortage in the West, because the Pacific Coast oil industry will do whatever is necessary to meet the demand. Already, some moves to bring in oil have started, and as individual companies get in short supply, the movement of oil into the West will increase.

The new Alberta oil fields are the most likely to become an early source of extra supply for the West Coast. The Trans Mountain Oil Pipe Line is now under construction and will be completed in 1954. The first movements will be to supply the British Columbia market, but the line is being built so that it can move up to 200,000 B/D. With present well-head prices in Canada and with the present import duty on imported oil, Canadian crude cannot be landed on the West Coast of the United States and compete with California crude oil at present prices, but these price differentials will somehow disappear if there is pressure from surplus producing capacity in Canada, or pressure from product demand on the coast.

If and when Canadian oil becomes an important source of West Coast supply, it will mean the development of an oil refining industry in the Pacific Northwest.

After Canada, the Uinta Basin of Eastern Utah is the next most likely source of extra supply for our area. This is largely an unexplored region, but some important discoveries have been made there and an aggressive exploration program is under way.

Other possible sources of important volumes of crude oil for our area are the western part of the Rocky Mountain region, Eastern Nevada, and the San Juan Basin of New Mexico, Colorado, Utah and Arizona. These basins are relatively unexplored and no important discoveries have been made, but they are large sedimentary basins with plenty of room for big oil fields.

The movement of West Texas crude oil to California seems impracticable when compared with the movement of Canadian oil to the Pacific Northwest. Logistics favor the Canadian movement by a wide margin.

As to our refinery situation, we have a statistical surplus of refining capacity. The quality of this surplus is poor, consisting mainly of straight-run units which cannot profitably operate at the existing levels of crude oil and products prices. There is some inefficient refining going on now, probably as much as there is efficient capacity in idle units. There is no overall excess efficient refining capacity in this district. Some new capacity is now being built, and additional capacity will be built, probably in the Northwest.

Also, regarding the pattern of product demand over the coming years, the light product requirements for gasoline and distillates will increase and the heavy fuel demands will decrease. It is likely that additional cracking facilities are going to be required in our refineries.

We are coming into a period in which crude oil productive capacity, refining capacity, and market demand are very close to being in balance each with the other. Some very large and important decisions affecting the future growth of the industry will have to be made. They will take foresight, skill and courage, but these are the things with which our industry is well endowed. We will continue to supply the people of this area with all of the oil products they wish for as long as they wish them, at prices which will not restrict or limit the growth of the area. Other factors, not the supply of energy or its cost, will determine how many people ultimately come here to live.

All of these forecasts are based on two hopes. These are (1) No general war engulfing the world; and (2) No further loss of freedom in the United States.

There is no limit to the wants of a free people in a peaceful world. Also, there is no limit to the ingenuity of the American oil industry to supply those wants if it can retain its freedom to plan, to risk, to try, to succeed, to fail, and try again. It can be done, but it cannot be done through war or through the bureaucratic restrictions on freedom, for which war is the excuse.

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SHIP'S BUNKERS are taking 25,000 B/D more of California oil since the begining of the Korean war. California's low bunker oil prices have contributed to this increased use.

FOREMOST

IN THE

GEOPHYSICAL

FIELD

DOMESTIC OPERATIONS

Western

GEOPHYSICAL COMPANY OF AMERICA

FOREIGN OPERATIONS

Western

GEOPHYSICAL COMPANY INTERNATIONAL

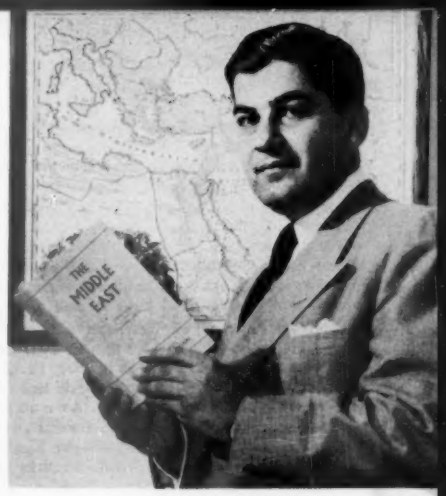
Henry Salvatori, President

PACIFIC MUTUAL BUILDING, LOS ANGELES 14, CALIFORNIA

SHREVEPORT, LOUISIANA • MIDLAND, TEXAS • CASPER, WYOMING

CALGARY, ALBERTA, CANADA • MILAN, ITALY • SAN JOSE, COSTA RICA

With net imports now running about 500,000 B/D, foreign oil has become increasingly important to the U. S. An adviser to both the government and private industry here analyzes . . .



Perils to the Free World's Essential Oil Supplies

By Walter J. Levy
Consultant

INCREASING DEPENDENCE OF THE FREE WORLD ON FOREIGN OIL

Since the beginning of World War II foreign oil has gained an ever greater importance in the oil supply of the United States and the other nations of the free world.* During 1939 this country produced over 3.6 million B/D of crude oil and related products, permitting, after satisfying domestic requirements, a net export of some 350,000 B/D. Beginning with 1948 the United States has been a net importer of oil, and during the first half of 1952, when production, at 6.7 million B/D, was over 85 per cent higher than 1939, the net imports of the United States amounted to some 500,000 B/D.

The most recent studies of the future development of the U. S. oil industry indicate that this trend toward an ever growing importance of foreign oil in the U. S. supply pattern will not only continue but is likely to be greatly reinforced. According to estimates of the President's Materials Policy Commission (PMPC), this country, by 1975, will produce 11.2 million B/D of crude oil and related fuels, including shale oil and other synthetics. Its requirements will be as much as 13.7 million B/D, necessitating net imports of 2.5 million B/D. As a result it is likely that the United States, which has in the past obtained the bulk of its imports from the Caribbean area, will in the future absorb not only the total surplus production in the other countries of the Western Hemisphere but will also require large supplemental quantities of crude oil from the enormously rich fields of the Middle East. Similarly the free countries in the Eastern Hemisphere, which procured a large portion of their oil needs before World War II from the United States and the Caribbean, import now over two-thirds of their greatly increased requirements from the Middle East and less than one-quarter from the Western Hemisphere.

This change in the supply position of the United States and free world is based on a fundamental shift in the relative size of proven crude oil reserves in the United States and in foreign oil-producing countries. At the end of 1938 U. S. reserves, at 17.3 billion bbl, constituted 61 per cent of total free world reserves of 28.5 billion bbl. By the beginning of 1952 proven crude reserves in the United States, although they had risen to 27.5 billion bbl, represented only 29 per cent of the reserves of the free nations, which had reached a total of 95.5 billion bbl. Foreign reserves, mostly located in the Middle East, had accordingly increased from 11.2 billion to 68 billion bbl. If the most recent estimates for Middle East oil reserves had been used, the latter figure would even be some 20 billion bbl higher.

As a result of the discovery of these vast new reserves, crude oil production in foreign countries after the end of the war could be expanded readily in response to the change in the supply position of the United States and to the rapid rate at which foreign oil consumption increased. Production in the Western Hemisphere countries outside the United States rose from some 1.3 million B/D in 1945 to 2.5 million B/D by the end of the first half of this year. By 1975, the PMPC anticipates that Western Hemisphere crude production outside the United States will amount to 5.9 million B/D and will exceed requirements by 1.3 million B/D. This excess will be available to help meet the deficit in the United States.

In the Eastern Hemisphere, production has expanded even more rapidly from about 600,000 B/D in 1945 to more than 2.6 million B/D by the middle of 1952 — and this in spite of the loss of over 600,000 B/D in Iran. In 1975, according to the PMPC, production may amount to as much as 9.7 million B/D, the great bulk of which will originate in the Middle East. The Eastern Hemisphere will thus be able not only to meet its own requirements fully but also to contribute 1.2 million B/D to the deficit expected to exist in the United States at that time.

The conclusion is inescapable that for peace, cold war or hot war, this country and the rest of the free world must rely heavily not only on supplies from the United States but also on the large-scale availability of oil produced in the other countries of the Western Hemisphere and in the Middle East.

WHO PRODUCES FOREIGN OIL

There is, first of all, the question of what countries and, secondly, of what companies produce foreign oil.

As to the first, it is significant that the bulk of foreign oil has been obtained in Venezuela and five underdeveloped nations or protectorates in the Eastern Hemisphere — Saudi Arabia, Iran, Kuwait, Iraq and Indonesia. A great deal has been written about the oil resources of these countries and in this context it need only be pointed out that by the middle of 1952, even with Iran not producing, they accounted for about

*All world figures comprise the free nations only and exclude the U.S.S.R. and satellites.

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80 per cent of the total foreign crude oil production of the free countries of the world.

As to the second question, it is equally significant that American and British or British-Dutch-owned companies are the producers of the preponderant part of the total oil output in foreign countries. These companies, several decades ago, obtained rights and concessions for the search and exploitation of oil, in many instances with the assistance and support of their governments. As a result of their initiative and investment they have discovered large foreign oil resources.

Crude production of American companies outside the United States amounted to 3.0 million B/D by the middle of 1952, over five times as much as in 1939. Production of British and British-Dutch companies meanwhile had about doubled to reach a level of 1.6 million B/D. As a result the share of American-controlled production in foreign countries increased during this period from 37 to 59 per cent of total output while that of the British and British-Dutch companies declined from 49 to 30 per cent, partly, of course, due to the events in Iran. The share of companies of other nationalities also declined from 14 to 11 per cent.

Particularly striking has been the increase in the share of American companies in Eastern Hemisphere production. It increased from 17 per cent in 1939 to 59 per cent by the end of the first half of this year, while the British share declined from 76 per cent to 33 per cent. In the Western Hemisphere outside the United States the share of American companies in production by the middle of 1952, at 58 per cent, and that of British and British-Dutch interests, at 28 per cent, showed only minor changes, as compared with 1939. It should be noted that the above percentages are in most cases determined in line with the stock ownership in producing companies rather than on the basis of the quantities of crude oil actually taken; that is, they do not allow for any long-term supply contracts between the various companies.

The American and British interests in foreign oil are held almost exclusively by five American and two British or British-Dutch companies, either singly or in various combinations of ownership. At different times smaller American and British corporations, as well as companies of other nationalities, have taken an interest in foreign oil development. With the exception of a few companies operating in Venezuela, however, their attempts to discover oil have either proved unsuccessful or their material resources have been too small to cope with the immense risks, to provide the necessary large investment, and to deal simultaneously with the political and commercial problems that confront all oil operators in foreign countries, and about which more will be said later. This has been strikingly illustrated recently when the Superior Oil Co. abandoned its offshore concession around Qatar and withdrew completely from operations in the Persian Gulf area because of the high cost of exploration, unfavorable general political conditions and some uncertainty regarding the legal status of concessions beyond territorial waters. Interestingly enough, the Royal Dutch-Shell Group was willing to assume these risks and has entered into a new concession arrangement for these areas.

THE CONTRACTUAL BASIS FOR FOREIGN OIL OPERATIONS

The most important foreign oil rights are held through concession contracts between the oil companies and the governments of foreign countries. The contracts usually cover very large areas and are of long duration, generally between 40 and 99 years. Of the six important foreign oil producing nations only Venezuela has a mining law establishing the ground rules for the issuance and operation of concessions. The Middle Eastern countries have granted oil rights on the basis of individual concession contracts with the companies. Traditionally the companies there have been granted a relatively large degree of freedom of management and operation, permitting them to produce and export in accordance with their commercial programs and needs without undue restrictions imposed by the producing countries. Under the concession agreements, the compensation to the government usually takes the form of royalties levied against production plus taxes on income. The terms, as recently revised in line with the pattern established in Venezuela, assure the producing country, in most cases, of about 50 per cent of the net profits from the operations.

The relatively great freedom of the oil companies to manage and operate their oil properties in foreign countries was essential to the success of the operations. This freedom was necessary, among other reasons, not only because of the backward state of the governmental machinery and other institutions in most of those countries, but also because risk capital could not otherwise be attracted on a sufficiently large scale.

As a result, foreign oil resources were available without undue restrictions to the companies in line with their programs and needs. Foreign oil has likewise formed a dependable and essential part of the oil supply of the free nations. World War II could not have been won without the free availability of foreign oil to the Allies, and the present cold war also could not be effectively conducted without it.

PROGRESSIVE STRESSES AND STRAINS HAMPERING FOREIGN OIL DEVELOPMENTS

The development of foreign oil resources in the postwar period has been increasingly affected by a series of new political and economic factors which were responsible for important changes in the basic arrangements between the producing countries and the operating companies. Many of these adjustments were called for by the newly developing political and economic conditions and, as such, do not raise any basic problems. What is most disturbing, however, is the emergence of excessive political and economic pressures which may well threaten to undermine the very basis for effective foreign oil operations. We may perhaps list the most important of these major forces.

There is, first of all, the decline of British power. This power had effectively maintained order in the Middle East and had directly supported British companies in their bargaining with the oil-producing countries there, thus indirectly benefiting American companies as well. The American Government has been reluctant to assert its power in a similar manner and the Middle East countries are keenly aware of this fact.

As a corollary to this development, there is the growing desire of the various oil-producing countries to subject their oil resources to direct national control and to formulate and carry out their own oil policies. Foreign investments in and control over basic raw materials invariably excite some envy and resentment. Local interests may easily be tempted to try to gain an increasing degree of control over these resources. In view of the newly awakened nationalism, particularly in the Middle East, and of the basic insecurity of those countries in the East-West struggle, such nationalistic tendencies have been greatly reinforced since the war.

In particular, the assertion by any oil-producing country of its power to cancel foreign oil concessions through nationaliza-

tion, as dramatically illustrated by events in Iran and by the lack of jurisdiction of the International Court in the Iranian case, may well have serious repercussions on the security of oil concessions elsewhere. Since the producing countries of the Middle East are actually unable to direct the complex technical and commercial operations of the oil industry, extreme interference would, on the one hand, hamper the development of badly needed oil resources. It would, on the other hand, jeopardize the flow of new foreign private investments which is so important for the future prosperity of underdeveloped countries and the stability of the free world.

In any case, the various oil-producing countries feel that their vast oil reserves should make it possible for them to gain a much greater international political and economic importance than their general standing in the council of nations and the strength of their underdeveloped economies would otherwise warrant. This possibility, they often feel, is enhanced by the East-West struggle which increases the dependence of the free world on their oil. Moreover, the strategic location of the Middle East countries and the power conflicts centering around them should enable them, so they believe, to achieve their own goals without the risk of intervention of either side by playing the East against the West.

The oil companies in their operations abroad must obviously abstain from any political activities. Accordingly, they must carry on their work in cooperation with the governments as they find them. Their neutrality will thus frequently give the appearance of support for the parties in power, be they honest or corrupt, enlightened or shortsighted, popular or despised. The standing of the local governments may thus easily affect the position of the companies.

Also, the oil industry represents, in most instances, the only large-scale and modern enterprise in the country. As such, it may give rise to political, social and economic strains, particularly in the otherwise ancient society and underdeveloped economy of Middle East countries. The revenue from oil operations is frequently the largest single source of income, and is, at least in part, the personal property of the rulers. In many cases effective budgetary controls of government income and expenditures do not exist. And the companies do not possess any direct influence to assure the use of the funds provided by them for the economic progress of the country and its people.

The rights governing foreign oil developments are usually established by a contract between the sovereign foreign power and the American or British company. In many instances the private corporation has proved to be increasingly at a disadvantage when issues arise between it and the foreign sovereign who has frequently the means of pliable legislation at his disposal.

In particular, each of the producing countries usually insists on as favorable arrangements with its oil industry as those granted by any company anywhere else, regardless of any special circumstances or the particular merits of the case. Accordingly, no adjustments in the concession terms can be made anywhere without sooner or later causing similar adjustments to be made everywhere. The flexibility necessary to achieve optimum results for all concerned is thus being lost.

The oil companies operating in foreign countries are inevitably affected by a number of additional considerations. As American or British corporations, for instance, they are subject to the laws and policies of their home governments. At the same time the various producing countries obviously expect them to abide by the local laws, policies and customs. Furthermore, the transit countries, through which the Middle East pipelines run, have their own set of conditions which they feel they should impose. The consuming countries, in turn, insist that the companies give predominant consideration to the interests of the importer. And finally, as corporations responsible to stockholders, the companies must, of course, also try to manage their affairs in line with commercial factors and possibilities.

FOREIGN OIL TRADE SUBJECT TO MANY DIVERSE CLAIMS

To illustrate some, but by no means all, of the diverse pressures on international oil operations, one may perhaps follow the various interests in the course of an oil transaction from a producing field in the Middle East to the market in Western Europe or the United States.

The producing country would like to obtain a maximum income from its oil. It is therefore interested in the largest possible royalty and also a high price, as such price would increase the profit of the operating company subject to its taxation. The country would, for the same reason, insist on maximum production and sales of its oil and also on the quickest feasible development of its reserves. Such pressure for production and sales may easily conflict with the desires or needs for outlets of other producing countries. It may also exceed the practical possibilities existing for the present operators to provide the necessary capital and markets, and it may interfere with their commitments in other producing areas. The producing country would also prefer to have its oil refined locally as this would increase the value of exports and result in additional employment and industrial activities. It would, further, like to receive its income to the greatest extent possible in hard currencies. Finally, it would be concerned with the destination of its exports, at least to the extent that such trade might affect its political or commercial interests.

The transit countries through which the pipe lines from the Persian Gulf to the Eastern Mediterranean are laid and through which the oil will pass are likely to make another series of requests of the operating company or the operator of the pipeline. They would ask for a maximum income from the pipeline operators; they would want their oil needs to be covered on favorable terms; and they, too, would try to establish some measure of control over the destination of exports, in accordance with their own political considerations.

The consuming and importing countries, in turn, would like to obtain the oil at the cheapest possible price. They would prefer to receive it as crude oil rather than as finished products in order to save foreign exchange and to provide employment and industrial development in their countries. In nearly all instances they would like to pay a minimum amount of hard currency and a maximum amount of soft currency. They would also be interested in procuring their oil from a variety of sources rather than from one producing country or company, in order not to become too dependent on a single supply basis. If the oil should be sold to the United States, its commercial fate would be affected by a further series of considerations related to the problems of security as well as the position of the United States domestic oil industry. In particular, welcome as foreign oil would be in the United States during periods when the gap between domestic supplies and requirements is widening, its arrival would be bitterly contested when this gap is narowing and great pressure would be exerted to limit its import.

The United States, as the parent country of the operating company, would, in its turn, insist that the foreign production,

transport, refining and marketing operations of the company be in accord with U. S. laws and policies. The United States would also be vitally interested, in line with its own political and commercial considerations, that the oil would always — in peace and war — be available to itself and to the countries of the free world.

There remains, finally, the operating company itself, which must try to satisfy all these partly, or even wholly, conflicting interests and which must still act under U. S. laws and policies and in accord with sound commercial principles. In this respect the producing company is obviously concerned with the problem of fitting its production and sales in any one country into its overall program for capital investment, production, transport, refining and sales.

Similarly, it is vitally interested in the safety of its investment, the return on such investment, its freedom of management, and its protection against any arbitrary requests or changes in operating conditions. It can probably never satisfy any single one of the various parties concerned completely without ignoring some claims of another interested group.

Thus the lot of the oil company engaged in foreign operations is indeed not an easy one. In view of all the pressures and obstacles facing American oil companies abroad, no one should have been surprised if the companies had never ventured into the field of foreign oil. But if the foreign oil resources had not been effectively developed or, even worse, if they had fallen under the control of a hostile power, the United States, the producing countries, and the whole free world would have been the poorer, and their survival in the present power conflict might well have been placed in jeopardy.

WHAT ABOUT THE FUTURE?

Undoubtedly the overriding strategic, political and economic importance of foreign oil, the conflicts centering around it, and the structure of the industry itself offer political, economic and legal problems of their own. The solution of these problems can only be achieved on the basis of an equitable reconciliation of all interests concerned. It is imperative to apply the rule of reason and to limit the requests and policies of each party to what is possible and feasible in the circumstances, taking into account that vital national and commercial interests, not only of the United States but of the whole free world, are at issue. Any other approach by the different parties could only jeopardize their entire position in foreign oil.

But there actually exists a great community of interest among the operating company, its parent country and the oil-producing and consuming countries. Each one makes a major contribution to the others' prosperity, economic stability and security, and none of them could actually do as well without the contribution of the others. Oil in the ground in the underdeveloped countries of the Middle East or elsewhere is of value to no one. It required the capital and skill of the American and British companies to bring it out of the ground — a skill and an investment that cannot presently be duplicated in the underdeveloped countries. It also requires the markets of the importing countries to translate the oil resource into an economic value. The cooperation of all is needed in order to assure the economic prosperity and the security of each one.

There are indications that an awareness of this basic community of interest is slowly developing, even though destructive forces tend to hide the constructive trends. In spite of, or perhaps even because of, the present turmoil about foreign oil the time has come, I believe, when another look should be taken at the problems of foreign oil and at possible ways and means of reconciling and protecting the interests of the United States, of the other oil-producing and consuming countries of the free world, and of the operating companies.

The first, though unsuccessful, attempt along these lines was perhaps made in 1944 through the negotiation of an Anglo-American oil agreement. This effort failed, largely because of the opposition of important segments of the U. S. Congress and of the U. S. oil industry which feared that such an agreement might be used to establish federal control over domestic operations and to promote an oil cartel. Much has happened since 1944, and it is obvious that foreign oil is becoming increasingly important to the free world, that it cannot be permitted to be treated like a political football in national policy or international relations, and that the issues and the stakes involved far transcend the interests and capabilities of any single party.

It is perhaps of interest to note that the same objections and fears which were previously raised in connection with an international oil agreement were also voiced at the time when the Interstate Oil Compact was first establishd in the United States. Since then the compact has proved to be a signal success. A great deal could perhaps be learned from a study of its operations, and some of it may well be of relevance for a solution of the grave problems of foreign oil.

In this connection some recent actions of the compact are of particular interest. The fact that the conservation of U. S. oil resources and the development of production and conservation in other countries of the Western Hemisphere are interdependent has influenced the compact to invite as official observers to its meetings the United States of Venezuela, Mexico, and the Provinces of Alberta and Saskatchewan in Canada. These invited parties have responded most cooperatively.

This action of the U. S. Compact might perhaps, as a first step, point the way to a future Pan-American approach to the problems of Western Hemisphere oil. The Western Hemisphere countries are linked by close economic and political ties and by common strategy in their defense against aggression from the outside. Together with the industry they may find new ways to cooperate voluntarily and without coercion, within appropriate fields, on such matters as the establishment of those basic facts which are essential for the conservation, and thus for the development, of their oil resources. Such activities must for their effectiveness depend completely on enlightened knowledge and the compulsion of mutual self-interest. But if successful, a Pan-American approach to the problems of Western Hemisphere oil may well become one of the most important bases for the political and strategic solidarity of the Western Hemisphere.

Similarly, in the Eastern Hemisphere, any apparent conflicts of interest among producing countries, consuming countries and the operating companies are actually far outweighed by the real and permanent community of interest among all of them. The Schuman Plan for the establishment of a European Coal and Steel Community gives hope that it may also be possible to resolve other economic and political differences and conflicting interests and issues affecting Eastern Hemisphere countries. While the problems of Eastern Hemisphere oil are in many respects very different from those of European coal and steel, there is no doubt that these problems, too, can and must be resolved equitably and peacefully.

Once all sides clearly understand and appreciate their own as well as others' problems, and provided there is good will on the part of all concerned, international oil, rather than leading to international frictions, should contribute to world understanding. ★ ★ ★

Technical Note 136—

PROCEDURE FOR USE OF ELECTRONIC DIGITAL COMPUTERS IN CALCULATING FLASH VAPORIZATION HYDROCARBON EQUILIBRIUM

H. H. RACHFORD, JR., JUNIOR MEMBER AIME, AND J. D. RICE, HUMBLE OIL AND REFINING CO., HOUSTON, TEX.

ABSTRACT

The effectiveness of digital computing machines in making technical calculations depends on how well the work is arranged to utilize the capability of the machines. This note presents a particularly useful way of calculating hydrocarbon vapor-liquid equilibrium in the flash vaporization (or condensation) system. The method is well suited to sequence-controlled computing equipment. It is not limited to equilibrium calculations and may be used for solution of most implicit equations in one variable.

INTRODUCTION

There is increasing interest in the use of electronic digital computers in research and engineering calculations. This is a fortunate and inevitable trend in view of both the increasingly extensive numerical work which is becoming a routine part of many daily production operations and growing demand for the overwhelming amounts of calculations required by newly developed numerical methods for solving heretofore unsolved problems.

Machines are in many ways ideally suited to the task but of necessity present certain difficulties, for a particular problem to be solved must often be formulated quite differently from the way it would be arranged for manual solution. This is done in order to take advantage of the inherent speed and precision of electronic computers and at the same time to limit the need for number storage to the capacity of the machine. Therefore, this note is submitted to present a general and quite powerful method of finding solutions of the frequently encountered implicit equation:

$$F(x, y_1, y_2, \ldots y_n) = 0 \quad \ldots\ldots\ldots \quad (1)$$

where the root, x_m, is to be found for a given set of $y_1 \ldots y_n$. The procedure is well suited for use with computing machines, for it usually requires but little storage or programming beyond that necessary to evaluate F.

HYDROCARBON EQUILIBRIUM

The method is described in terms of the problem it was designed to solve, *i.e.*, the calculation of hydrocarbon vapor-liquid equilibrium in flash vaporization. Given the composition of a hydrocarbon mixture and appropriate values of the equilibrium ratios K, to find the phase ratio and compositions in a closed system: let z_i be the mol fraction of the i-th component in the mixture. If K_i is the ratio y_i/x_i, where y_i and x_i are the mol fractions of the i-th component in the vapor and liquid phases, respectively, then by material balance

$$z_i = Lx_i + VK_ix_i \quad \ldots\ldots\ldots \quad (2)$$

where L and V are the mol fractions of the components in the liquid and vapor, respectively. Since $L = 1 - V$, the relations follow

$$y_i = \frac{K_iz_i}{(K_i-1)V+1} \quad \ldots\ldots\ldots \quad (3)$$

$$x_i = \frac{z_i}{(K_i-1)V+1} \quad \ldots\ldots\ldots \quad (4)$$

Manuscript received in the Petroleum Branch office Sept. 11, 1952.

By a total material balance for an S-component system

$$\sum_{i=1}^{S} y_i = \sum_{i=1}^{S} x_i = 1 \quad \ldots\ldots \quad (5)$$

or

$$\sum_{i} (y_i - x_i) = \sum_{i} \frac{(K_i-1)z_i}{(K_i-1)V+1} = 0 \,. \quad (6)$$

Equation (6) is of the form of (1)

$$F(V, K_1, K_2, \ldots K_n, z_1, z_2, \ldots z_n) = 0 \quad \ldots \quad (1')$$

and for any set of K_i and z_i must be solved for root V_o.

From physical considerations it is necessary to study only the region $0 < V < 1$, and it is known that only one, if any, root

Continued on Page 3, Section 2

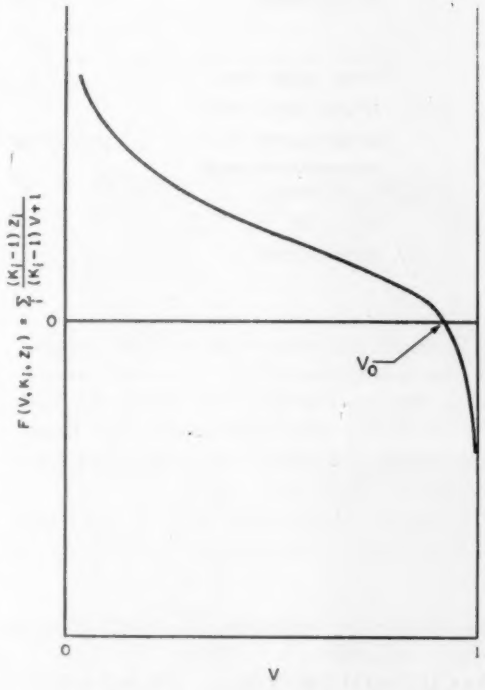

FIG. 1 — FUNCTION DEFINED BY EQUATION 6.

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West Coast Meeting Program

Statler Hotel, Los Angeles, Calif.

Thursday, October 23

8:00 a.m. to 5:00 p.m. — Registration and Exhibits

9:00 a.m. — Technical Session — Ballroom 3

Chairman — M. B. STANDING;
Vice-Chairman — C. FERGUSON

245-G: *Equilibrium Considerations in Two Phase Flow of Fluids Through Porous Media*, by J. A. PUTNAM, University of California, and H. H. ABOUL-SEOUD.

246-G: *Application of PVT Data to Reservoir Engineering*, by C. R. DODSON, University of Southern California, DAVID GOODWILL and E. MAYER, Standard Oil Co. of California.

10:30 a.m. — Business Meeting — Basil Kantzer, Chairman

247-G: *Some Theoretical Considerations of Tilted Water Tables*, by SAM T. YUSTER, University of California at Los Angeles.

12:00 m. — Petroleum Chapter Luncheon — Ballroom 2 — Joseph Jensen, Presiding
Speaker: Frank P. Doherty, civic leader and attorney

2:00 p.m. — Technical Session — Ballroom 3

Chairman — C. R. DODSON;
Vice-Chairman — ELMER DeMARIS

248-G: *The Estimation of Water Injection Profiles from Temperature Surveys*, by T. J. NOWAK, Union Oil Co. of California.

2:45 p.m. — Water Flood Discussion — Ballroom 3

Panel members: JOHN DODGE, moderator; MORTIMER KLINE, legal; HARRY AGGERS, management; R. C. EARLOUGHER, applicability; R. HAWKINS, plant equipment; and J. MILLER, expectations.

Friday, October 24

8:00 a.m. to 5:00 p.m. — Registration and Exhibits

9:00 a.m. — Technical Session — Ballroom 3

Chairman — W. S. EGGLESTON;
Vice-Chairman — R. MANGOLD

249-G: *Ionic Double Layer Conductivity in Reservoir Rock*, by W. O. WINSAUER and W. M. McCARDELL, Humble Oil and Refining Co.

250-G: *Preparation of Engineers for Management*, by DOUGLAS WATSON, McKinsey and Co.

251-G: *Gas Storage in the Playa Del Rey Oil Field*, by JOHN RIEGLE, JR., Southern California Gas Co.

12:00 m. — Southern California Section Luncheon — Ballroom 2
Speaker: J. R. "Bill" Pemberton, consultant

2:00 p.m. — Technical Session — Ballroom

Chairman — MASON L. HILL; Vice-Chairman — L. LIEDHOLM

252-G: *Salinas Valley Correlation Section*, by J. E. KILKENNY, Union Oil Co. of California.

253-G: *San Ardo — A Geologic Case History*, by T. A. BALDWIN, Monterey Oil Co.

254-G: *Engineering Case History — San Ardo*, by HOLMES MILLER, The Texas Co.

255-G: *Analysis of Pressure Build-up Data*, by G. B. THOMAS, Signal Oil and Gas Co.

8:00 p.m. — Annual Banquet and Dance — Ballroom 2

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Dinner Dance Chairman

ABSTRACTS OF PAPERS TO BE PRESENTED AT THE WEST COAST FALL MEETING

245-G

Equilibrium Considerations in Two-Phase Flow of Fluids Through Porous Media

John A. Putnam, University of California, Berkeley, Calif., and **Hassan H. Aboul-Seoud**, Egyptian Bureau of Mines, Cairo, Egypt

The basic assumption of the attainment of phase equilibrium, required in the study of multiphase flow in porous media, is investigated for a single-component system. Equilibrium requires, at any cross-section normal to the flow, the existence of a uniform temperature between phases and a unique relation between this temperature and the vapor pressure. The deviation from a uniform temperature between phases is shown to be of negligible order. By use of an expression for the rate of evaporation it is shown that the density of the vapor phase differs from its density under equilibrium conditions by an infinitesimal amount. These results, substantiated by experimental evidence, lead to the conclusion that the assumption of phase equilibrium for a single-component fluid is valid. It is pointed out that this assumption cannot be extended to multi-component systems without further research.

246-G

Application of Laboratory PVT Data to Reservoir Engineering Problems

C. R. Dodson, University of Southern California; **D. Goodwill**, Standard Oil Co. of California, La Habra; and **E. Mayer**, Standard Oil Co. of California, Tupman, Calif.

The paper summarizes the historical background of the pressure-volume-temperature analyses of reservoir fluids, the errors involved in both the sampling and testing of reservoir fluids, the type of information required of a P-V-T determination, and the field conditions that limit the application of any one analysis results. Particular emphasis is placed on the necessity for approximating as closely as possible the liberation sequence occurring in the producing formation, flow string, and surface separators. A combined differential and flash or "composite" liberation is suggested as the best means of approximating this liberation sequence.

247-G

Some Theoretical Considerations of Tilted Water Tables

S. T. Yuster, University of California at Los Angeles

An analysis has been made of the factors responsible for tilted fluid contacts in petroleum reservoirs. The factors are static and dynamic with the former being controlled by those variables responsible for the capillary rise of fluids and the latter include rate of formation tilt and hydraulic circulation. The explanation that rate of formation tilt may be responsible for tilted contacts appears untenable. The role of some of these factors in the migration, fractionation, accumulation, and possibly the prospecting for oil is indicated.

248-G

The Estimation of Water Injection Profiles from Temperature Surveys

T. J. Nowak, Union Oil Co. of California, Brea, Calif.

The heat flow processes determining the injection and shut-in temperature logs in a water injection well have been analyzed and the theoretical basis for determining the water injectivity profiles from the temperature logs has been presented. Both the injection and the subsequent shut-in logs are necessary to resolve the injection interval into relative water intake strata; the former, to provide an accurate estimation of the thicknesses of the strata, and the latter to indicate the major and minor intake rates into the strata. A procedure is described for estimating the injectivity profile from the temperature logs and the geothermal gradient and is applied to several temperature logs. For a water injection well, a comparison is made of the injectivity profiles obtained from the core analysis, the spinner survey, and the temperature logs.

249-G

Ionic Double Layer Conductivity in Reservoir Rock

W. O. Winsauer and **W. M. McCardell**, Humble Oil and Refining Co., Houston, Tex.

The abnormal conductivity found in shaly reservoir rocks containing an electrolyte is shown to be a consequence of the electrical double layer in the solution adjacent to charged clay surfaces. This increased conductivity results from a higher concentration of ions in the double layer than in the solution in equilibrium with the double layer. It is shown that the magnitude of the increased conductivity of a shaly reservoir material is influenced by the concentration and type of ions in the equilibrium solution as well as by the colloidal nature of the rock.

250-G

Preparation of Engineers for Management

Douglas Watson, McKinsey and Co.

Technological developments during the last decade have brought many more engineers into American industry; the growing importance of industry based on the application of complex engineering knowledge has posed severe management problems. Once past the developmental stage, technical industry requires administration — or "management." The logical source for this management is the engineering profession. But all too often engineers make poor administrators. Trained in the scientific approach, they have difficulty in dealing with the emotional and subjective aspects of management. Intensively trained in the technology of a limited engineering field, they must "know more and more about less and less" if they are to succeed as engineers. Yet the administrator must know a fair amount about a lot of things. What can be done in this paradoxical situation? By examining successful executive development programs a clue can be found. By considering the problem of making the engineer a successful administrator from the viewpoint of the engineer himself, ways can be developed to prepare him for management. Industry requirements in terms of sound organization structure are also explored. The technique of management appraisal is examined as a means of inventorying engineering executive talent. Finally, in the light of the unusual requirements of the engineer, the specific methods of developing engineering executives are evaluated — both from the viewpoint of the company and the man. If we are to capitalize on the present technical developments, we must have more able engineer-managers. It is not enough to have engineering talent at the design and development stage — we have to know how to handle these engineering works. A realistic approach to preparing engineers for management will benefit individual and company alike.

251-G

Gas Storage in the Playa Del Rey Oil Field

John Riegle, Jr., Southern California Gas Co., Los Angeles, Calif.

To date utility company underground storage of gas has generally been restricted to depleted dry gas fields. The Playa Del Rey project is probably the first to store gas successfully in a partially depleted oil reservoir with the recovery of large volumes of gas at high rates as the main objective. Oil recovery has been a scondary consideration. Problems encountered unusual to those of storage in a dry gas zone were: (1) the removal and retardation of formation of emulsion, (2) the upstructure movement of fluid during withdrawal periods which formed fluid blocks, and (3) reservoir shrinkage resulting from encroachment of edgewater. The solution of these problems as outlined in the paper has resulted in increasing the withdrawal rate from the original design capacity of 4,000 Mcf per hour to the current 10,000 Mcf per hour. Additional increase is anticipated as the operations continue. Migration, reservoir performance, operational procedure and a historical record are included to make this a resumé of the project from its war time inception in 1942 to the first of this year.

252-G

Salinas Valley Correlation Section

J. E. Kilkenny, Union Oil Co. of Calif.

This correlation section is one of a series prepared by the Geologic Names and Correlation Committee of the AAPG under the chairmanship of R. T. White. It extends in a general SW-NE direction across the Salinas Valley sedimentary basin passing through the San Ardo Oil Field and terminating at the San Andreas fault. The section exemplifies some of the problems of geologic nomenclature in an area of rapid facies changes and extreme variations in the thickness of Tertiary sedimentary units.

253-G

San Ardo — A Geologic Case History

T. A. Baldwin, Monterey Oil Co.

San Ardo oil field is the world's largest commercial reserve of heavy oil; probably the largest addition to Pacific Coast reserves in the last ten years. Discovery of this vast accumulation resulted from persistent geologic studies and courageous drilling. Geology has also played a dominant role in analyzing peculiarities of the reservoir. The present and future development of the field will undoubtedly be planned by a close liaison of geologic and engineering techniques.

254-G

Development History — San Ardo Field

H. O. Miller, The Texas Co., Los Angeles, Calif.

Experience gained in early development showed the necessity of completing wells with gravel packed slotted liners. It also showed that water coned up rapidly and that wells should be bottomed a considerable distance above the water table. Lombardi Sand producers are bottomed a minimum of 75 ft and Aurignac wells a minimum of 50 ft above water. It is necessary to cement the casing approximately 20 ft below the gas-oil interface to prevent downward coning of gas. Lost circulation is experienced to a depth of approximately 500 ft in the hills west of the Salinas River. It was necessary to provide protection from high water in the river bottom. Wells have been deflected as much as 500 ft under the river without difficulty. The Lombardi Sand has a gas cap 20 ft in thickness and a maximum oil column of 230 ft. Its average porosity is approximately 33 per cent and its permeability is approximately 4,000 md. This crude varies in gravity from 10.6° to 12.1° API at 60°F. Its viscosity is 300,000 Saybolt Universal Seconds at 80°F and its pour point is 55°F. Gas/oil ratios vary between 15 and 100 cu ft/bbl. The original bottom hole pressure was approximately 900 psi. The 242 Lombardi wells completed to date have produced approximately 5,400,000 bbl of oil. Two small gas cap areas exist in the Aurignac Sand. These are not well defined. This sand reaches a maximum productive thickness of approximately 200 ft. Its average porosity is approximately 30 per cent and the average permeability is approximately 1,350 md. The crude gravity varies from 12° to 13.5° API at 60°F, whereas its viscosity is 26,000 Saybolt Universal Seconds at 80°F. Its average gas/oil ratio is approximately 85 cu ft/bbl. The bottom hole pressure of the Aurignac reservoir was approximately 1,000 psi originally. The 116 Aurignac wells now completed have produced approximately 2,300,000 bbl of oil. Surface facilities have been specially designed to handle these low gravity high viscosity crudes. Lead lines are designed to provide for individual well gauges. Pumping equipment is installed initially with electric motors for prime movers. It is necessary to heat the oil to 180°F to break down the foam and facilitate shipment. Four barrels of storage is required for each daily barrel of oil produced. Stock tanks are insulated and provided with steam coils. Hot crude oil is blended with gas oil cutter stock when delivered to the pipeline. An eight-in. pipeline delivers blended crude to Estero Bay and a four-in. line returns cutter stock to San Ardo.

255-G

Analysis of Pressure Build-Up Data

G. B. Thomas, Signal Oil and Gas Co., Los Angeles, Calif.

Several methods of analyzing pressure build-up data in wells have been presented in recent years by various authors. This paper reviews the theory and method of D. R. Horner given in his paper "Pressure Build-Up in Wells" presented at the Third World Petroleum Congress at The Hague in 1951. Example calculations are performed on data obtained by testing several types of wells. These calculations include, (1) graphical estimation of final static pressure, (2) determination of the productive capacity of the pay away from the well bore and, (3), estimation of the degree to which the formation adjacent to the well bore has been damaged by completion or other causes. Methods of testing and precautions which should be taken to assure the best data possible are discussed. Limitations and reliability of calculated results are also treated.

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HYDRIL CO.	9
JOHNSTON TESTERS, INC.	23
LANE - WELLS CO.	14
MARTIN - DECKER CORP.	24
McCULLOUGH TOOL CO.	10
NICHOLAS A. D'ARCY, JR.	20
RAPID BLUE PRINT CO.	19
SCHLUMBERGER WELL SURVEYING CORP.	Coffee Bar

Minutes before the Welcoming Luncheon, Branch Chairman Paul Turnbull, Gulf Coast Chairman George Gray, and Meeting Chairman Buck Morris (below) double check their busy day's agendas . . . Reading clockwise, Morris gets a preview of W. K. Whiteford's Luncheon address . . . Members fill the Rice Ballroom during a Well Completion session . . . G. T. Yates receives the Membership award for the Kansas Section from Membership Chairman Jack Moore.

Record Crowd Attends

One of the most successful Fall Meetings of the Petroleum Branch, AIME, was concluded early this month in Houston, Tex. Measured by attendance figures alone, it could be considered the Branch's most successful meeting. Some 1,533 members, junior members, associates and students registered for the three-day session of 40 technical and economic papers Oct. 1 - 3. In addition, 287 ladies and guests of members were registered.

These registration figures represent approximately a 50 per cent increase over the previous record Fall Meeting attendance. A number of conditions were responsible for the large turnout of members. The fact that the meeting was held in Houston, one of the nation's chief oil centers, was a big factor. A large number of Petroleum Branch members are concentrated in Houston and surrounding cities and their attending the meeting presented no problem. However, probably the largest contribution to the success of the meeting was the high quality of the papers and the prominence of the authors and speakers. The Technology Committee is due the congratulations of the Branch for its selection of the outstanding material presented.

Random Notes . . .

The Annual Branch Banquet held in the Rice Hotel's Ballroom took on the appearances of the Annual Institute Banquet held last February in New York City's Waldorf. Institute Secretary EDWARD H. ROBIE remarked that the occasion was one of the most successful Branch social affairs he had seen in some time . . . Registration of the record attendance went smoothly considering the facilities. Registration Chairman HERMAN A. OTTO was a candidate for the busiest member in Houston. Prior to the meeting he was convinced that his task was an impossible one. Once the meeting was underway, he realized that his committee members were as efficient a group as could be desired . . . W. S. (BUCK) MORRIS, general chairman of the meeting, took advantage of the concentration of petroleum men to publicize Kilgore's upcoming "Jub-Oil-lee." Buck was passing out cigarette holders by the hundreds plugging the East Texas oil show . . .

R. L. LINDAUER, JR., co-chairman of the meeting arrangements committee, was on the run constantly with the task of keeping each session supplied with projectors, operators, pointers, etc. . . . Compliments were heard on the program of the Economics Session, which was arranged by KENNETH E. HILL and his committee.

Houston Fall Meeting

GEORGE R. GRAY, chairman of the Gulf Coast Section, modestly told everyone his committee workers were responsible entirely for the smoothness with which the meeting progressed. . . . DUVALL WILLIAMS claimed that Core Lab's coffee bar served more coffee in one morning than it had in any one day at previous meetings. Reason: Duvall set up a television set for World Series fans . . . R. M. DARLING, co-chairman of the hotels committee, was bemoaning the fact that his work was never done. After bedding everyone down, his committee became the "hospitality committee."

Everyone was complimenting KENNETH B. FORD and his entertainment committee for the good taste in entertainment functions . . . Houston newspapers were courting J. E. (HANK) KASTROP'S publicity committee for information on W. K. WHITEFORD'S welcoming luncheon address and WALTER J. LEVY'S general session paper. Last thing WHITEFORD did before returning to his Pittsburgh office was to drop by the AIME headquarters room in the Rice for a copy of the Levy paper . . . Three days after the meeting, by the way, requests were still coming in from the nation's press for copies of Levy's paper.

From all reports, the field trip to Texas Gulf Sulphur's facilities at Newgulf, Tex., was a large success. The hospitality of H. E. TREICHLER, vice-president and general manager, is still being applauded . . . The GAIL MOULTONS were eagerly awaiting the arrival of Saturday, Oct. 4, and a side trip to Austin, Tex., for the University of Texas-Notre Dame football game . . . CLAUDE R. HOCOTT, chairman-elect of the Petroleum Branch, AIME, gave the invocation prior to the welcoming luncheon. JOHN R. MCMILLAN, remarking on the good job done, expressed his unawareness of Claude's clerical background . . . Incidentally, Claude received one of the warmest rounds of applause on record when announcement was made of his election to the chairmanship for 1953 . . . Perennial meeting goers were greeted by MRS. STUART BUCKLEY with "Why, the last time I saw you was in a taxi in New York last February . . . "

Apologies are due those who failed to receive preprints. The Branch office in Dallas calculated for a record turnout of some 1,200 instead of a record turnout of some 1,500 . . . The same error will be avoided next year, it is hoped, when the Fall Meeting will be held in Dallas . . . Physical laws are sometimes reversed at crowded meetings. In the case of elevator service from the mezzanine floor of the Rice Hotel, all things that went up first had to go down . . . to the main floor via stairway in order to catch one of the crowded lifts. ★

New Branch Chairman Claude Hocott, John Bell and 1952 Chairman Paul Turnbull discuss Branch business (upper left) . . . Reading clockwise, the open meeting of the Executive Committee . . . Mrs. Paul Turnbull, Mrs. George Nye and Mrs. A. S. Parks entertain at Ladies' Coffee . . . Alvin Geyer, the 1500th registrant, gets his badge from Dorothy Wisenbaker, while Registration Chairman Hermann Otto tallies the day's record-breaking attendance receipts.

Gulf Coast Cementing Practice

Reported by R. H. Burke
Pacific Junior Group

Vernon R. Young, division engineer for Halliburton Oil Well Cementing Co., spoke before a recent meeting of the Pacific Petroleum Chapter's Junior Group. A former district engineer for the company in Louisiana, Young compared cementing practice in the Gulf Coast area with California practice.

Specifically, he limited his discussion to the territory covered by the Southeast corner of the Gulf Coast, or Louisiana and Mississippi. Highlights of Young's remarks are summarized below.

In this area, the wells vary from 300 ft to below 15,000 ft in depth. The formations run from hard sands, limestones, or chalks to loose unconsolidated sands. The temperatures range from 100°F to above 350°F. It is impossible, therefore, to have one set cementing program to meet all these conditions.

There are, however, a few standard practices throughout the area. Production strings are generally 5½ in. to 7-in. casing and hole size 7⅞ in. to 9¾ in. The surface pipe is usually 10¾ or 9⅝ in. Two plugs are used while cementing and the top plug is pumped to a shutoff. The pump down rate is as fast as practical, and both rig pumps and cementing pumps are used. No measurements are made during pump down as the top plug is pumped to a shutoff. Mechanical cleaners and centralizers are used. The casing is generally set through the production zone and gun perforated. Often the top plug is below the productive interval, and is not drilled out.

The remaining variables are the cementing materials, and the methods of mixing and handling.

Coastal Region with Miocene Sand

In this area the wells are deep, frequently from 12,000 ft to 15,000 ft. The temperature gradient is 16° to 17°F per 1,000 ft. Standard practice is to use a slow setting cement. On the deeper wells a retarder is added either to the mixing water or to the dry cement.

The Miocene sands are soft and carry a high pressure. It is necessary, therefore, to follow a strict mud program. The mud and the hole condition governs the weight of the cement. Low percentages of bentonite are used in the cement.

Wilcox-Eocene Formations of Central Louisiana

These formations resemble some California sands, but are much thinner, having a producing thickness of less than 50 ft. The producing sands are generally interbedded with shale.

Water may be found below, above, or within the producing sands and increases the difficulty of obtaining a good cement job. The temperatures in this area are lower than those of the coastal region, and a slow setting cement gives ample pumping time. It was an early practice to use gypsum cement ahead of the standard batch. The gypsum cement would be displaced to behind the pipe and then allowed to set. The standard batch was then squeezed behind the gypsum cement.

Lost circulation materials and gel cements have also been used. The shales and volcanic ash of the formations in this area dissolve in fresh water or the filtrate from the cement and make it difficult to obtain a cement job that does not fail. To decrease this tendency, 10 per cent salt solutions or formation water has been used ahead of the cement and for mixing water.

Remedial work is very difficult and as many as 17 stages have been used in order to obtain a successful job. A single packer is generally used above the point to be cemented. The success of these remedial works depends largely upon the success of the primary job.

Gel cements, perlites, salt solutions and low water loss cements are all being considered for further work in solving the problems of this area.

Upper Cretaceous of Mississippi and North Louisiana

These formations range in depths from 2,000 ft to below 10,000 ft. The secret of cementing in this area is the isolation of the zone, tailor-made cement containing up to 12 per cent gel, multiple stage cementing, and block squeezing. Low water loss cements are used in remedial work. In this area the initial job also has a significant bearing on the success of the squeeze job.

Lower Cretaceous

Here the formations grade into harder sands. There are high pressure zones with weak zones above and therefore, the ever present danger of blowouts. This condition has caused attention to be called to proper mixing. In one field, success has been gained by first mixing a heavy cement and following this with normal cement. A five per cent phosphate solution is used ahead of the cement.

Jurassic

These formations grade from hard sands to oolitic lime. Primary cementing is not too difficult. The lime resists squeezing in remedial work. Water may be injected into these limes at relatively low pressures, but the coarser materials of cement will not squeeze. Only five or six sacks at a time can be put away.

The outstanding differences between California and the Gulf Coast are the formation thicknesses which sometimes in the Gulf Coast may be only three to four ft of zone, while in California thicknesses are much greater. The formation pressures of the Gulf Coast are generally much higher than in California. The hole size and casing used in the Gulf Coast are smaller than in California and a closer fit between casing and hole is generally the practice in the Gulf Coast. Formation temperatures in the Gulf Coast region may be as high as 389°F. In the Gulf Coast region it is common practice to set through the zone and gun perforate while in California common practice is to set above the zone and run perforated liner. In California the tendency is to use higher percentages of lost circulation materials.

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NATURAL GAS IN THE PROVINCE OF ALBERTA, CANADA

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ABSTRACT

The status of the natural gas industry in Alberta, Canada, is described with particular reference to the current extent of natural gas reserves and possibilities for additional development. Certain major fields are discussed as representative of the types of gas accumulations within various broad geographical divisions of the provinces. The estimation of the future performance of a gas reservoir is discussed as the basis for an estimate of the future availability of natural gas from presently known reserves. The future availability of the provincial reserves and the estimated future demand for gas within the province are described.

INTRODUCTION

This paper is a condensation of a detailed study of the natural gas reserves and the future availability of pipeline gas in the province of Alberta as prepared for Trans-Canada Pipe Lines Limited and presented in public hearings at Edmonton and Calgary before the Petroleum and Natural Gas Conservation Board of the Province of Alberta. The study began in October, 1950, and resulted in the preparation of five volumes of data at the expenditure of more than 20,000 man-hours. This paper is designed to afford a broad picture with detail limited to a type example of both natural gas accumulation and future availability of gas supply.

The province of Alberta has an area of 255,285 square miles which, for sake of comparison, is 8,359 square miles smaller than the state of Texas. Natural gas was first discovered in 1883 at the now abandoned Alderson well located some 20 miles southeast of the town of Princess. The first gas in commercial quantities was found at Medicine Hat in 1890. During the last 68 years, 187 localities have been discovered which are capable of gas production, and 73 per cent of these have been found since 1945. Sixty fields currently are producing gas, including 22 non-associated gas accumulations.

Location of the oil and gas fields and prospects in the province of Alberta is shown in Fig. 1, together with a list of the localities of measurable gas, Fig. 1A.

The estimated total provincial gas reserve as of Jan. 1, 1952, for the 104 fields estimated, is 11.7 trillion cu ft proved and probable, and for the 187 known areas capable of production is in excess of 16 trillion cu ft on a total proved, probable, and possible basis. Five fields (Pincher Creek, Leduc-Woodbend, Viking-Kinsella, Cessford and Medicine Hat) are estimated to have recoverable reserves of more than one trillion cu ft each. A sixth field, Turner Valley, was initially in this group, but its reserves have been depleted substantially. Twenty-four fields, of which the above mentioned six fields are a part, have estimated gas reserves (including the possible category) in excess of 100 billion cu ft. These 24 fields account for 79 per cent of the total provincial reserves.

Comparative systemic analyses reflect that 56 per cent of Alberta's gas reserves are contained in sediments of Cretaceous age; 30 per cent in sediments of Mississippian age; 10 per cent in sediments of Devonian age; three per cent in sediments of Triassic age; and the remaining one per cent in Jurassic and Permo-Pennsylvanian sediments. It is expected that the relative importance of the Mississippian, Devonian, and Triassic sediments will be increased as exploration progresses.

GENERAL GEOLOGY

The western Canada basin comprises the sedimentary area between the Canadian Shield and the Rocky Mountain Front Range, the Arctic Ocean, and the International Boundary. The basin has an approximate area of 765,000 square miles and embraces parts of the provinces of Manitoba, Saskatchewan, Alberta, British Columbia and the Northwest Territories.

Generalized columnar sections for the Province of Alberta are shown in Fig. 2. Substantially all of Alberta, except its northeast corner, has sedimentary cover. Sediments of all the geologic systems are represented, except those of Silurian age.

[1]References given at end of paper.

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Ordovician sediments are present only in the Rocky Mountain belt of Alberta and in the southeastern corner of the province. Great thicknesses of Tertiary sediments occupy parts of the Alberta syncline, but this interval represents a small portion of Tertiary time. Throughout about one-half of the province, in the north and east parts, Cretaceous sediments rest directly on Devonian rocks.[1,2] The two principal overlapping rock units are of Cretaceous and Upper Devonian age. In a northeast-southwest line (normal to the regional strike) between the Foothills Belt and the Canadian Shield, Cretaceous sediments overlap progressively the stratigraphic section from Jurassic to pre-Cambrian. East of the Alberta syncline, the sediments of Jurassic through Mississippian thin to zero forming several wedge-out belts many hundreds of miles in length. Throughout some 20,000 square miles of the Peace River Ridge, Devonian rocks rest on the pre-Cambrian. Over the apical area of this ridge, high Upper Devonian sediments rest on pre-Cambrian, with successively older Devonian rocks developing flankward.

GEOLOGIC HISTORY

The sedimentary history of the Western Canada Basin has been discussed in considerable detail in a recent paper by J. B. Webb.[3]

The major portion of the clastic sediments composing the sedimentary section of the province of Alberta was derived from the west. During certain depositional periods these sediments were deposited relatively close to the present Rocky Mountains, while at other times the seas extended into Saskatchewan or beyond. A relatively small thickness of clastics present in eastern and central Alberta were derived from the Canadian Shield.

Lower and Middle Cambrian sediments accumulated in the Cordilleran geosyncline which later became the site of the present Rocky Mountains. Upper Cambrian time witnessed general submergence of the province and the usual succession of Upper Cambrian sediments, so characteristic of central North America, were deposited. From the end of the Cambrian to the beginning of the upper Devonian, Alberta was mostly emergent except for local deposits of Ordovician and the development of a deep Middle Devonian evaporite basin in the eastern portion of the province. During Upper Devonian time the presence of shallow seas over most of the central region of Alberta made possible the widespread growth of reefs.

Between the beginning of Upper Devonian and the beginning of Cretaceous time, the province of Alberta east of the Rocky Mountain Front Range was generally an area of subsidence in the Foothills Belt and was emergent throughout most of the rest of the province. Important exceptions were the accumulation of Devonian and Mississippian sediments in the southeastern portion and parts of the central portion of the province. Although sediments of Triassic age are present generally throughout the Foothills Belt, it is significant that in the isolated Peace River Basin great thicknesses of marine Triassic accumulated.

During all Cretaceous time, thick sediments were deposited in Alberta. Much of this was due to marine transgression but occasional continental deposits are in evidence, especially in the upper portion of the Blairmore. Climate favorable to deposition of coal and conditions favoring the presence of volcanic ash were widespread.

Thick Tertiary sediments accumulated in the Alberta syncline. These, however, represent only a small portion of Tertiary time, and most of Alberta was emergent during the Cenozoic and continued erosion developed the physiographic features which characterize the present topography of the province.

The principal periods of orogeny were the Nevadan Revolution at the close of the Jurassic and the Laramide Revolution at the close of the Cretaceous which culminated in the development of the Rocky Mountains and the deepening of the Alberta syncline.

STRUCTURAL CHARACTER OF THE PROVINCE

The principal structural alignment of Alberta is northwest and southeast. Many of the local producing structures are superimposed on these regional folds and have a more north-south trend. The chief structural features are the Rocky Mountains, the folded and faulted Foothills Belt,[4,5,6] the Alberta syncline, the Sweetgrass arch, the Alberta shelf, the Moose Jaw-Mackenzie syncline, and the Peace River Ridge.

The Alberta shelf, instead of being a single homocline, appears to consist of a series of semi-parallel northwest-southeast regional anticlines and synclines of low relief which persist for long distances and develop shallow local closures. Some of the Devonian reefs are associated with these axes, and their orientation generally follows a structural pattern.

While many of the known tectonic features of Alberta have Paleozoic counterparts and result from several periods of recurrent movement, the principal orogeny took place in Nevadan and Laramide time. The Alberta shelf area is characterized by gentle folding, and no great subsurface structural features are known which are similar fo those prevalent in the Mid-Continent area of the United States. The closest approach to such a feature is the Peace River Ridge.

RELATIVE IMPORTANCE OF RESERVOIR TYPES AND THEIR STRATIGRAPHIC DISTRIBUTION

Most of Alberta's oil and gas fields have been discovered so recently that it is still too early to name the controlling factor in reservoir traps and recovery mechanisms. Despite incomplete data, certain generalized trends suggest the relative importance of structural *vs* stratigraphic traps and depletion *vs* waterdrive recovery mechanisms of these gas accumulations.

Structurally controlled accumulations relatively uncomplicated by elements of stratigraphic trapping, are limited in number and distribution. The Madison reservoirs of the Foothills Belt are structurally controlled. The oil reservoirs in the Joseph Lake and Excelsior fields are localized by structural closure. A few of the basal Cretaceous and Viking gas reservoirs of the Central and Southeastern Alberta Plains are structurally controlled.

Stratigraphically controlled reservoirs and composite reservoirs (both stratigraphically and structurally controlled) dominate the Central and Southeastern Alberta Plains. Type examples of stratigraphic reservoirs are those in the Viking-Kinsella, Medicine Hat, and Pendant d'Oreille Fields, and

MESOZOIC
LOWER
BLAIRMORE GROUP
KOOTENAY
Fort St John
Bullhead
Hasler
Commotion
Peace River
Continental Sand
Cadotte Sand
Harmon Shale
Notikewin Sand
Farrell Shale
Gates Sand (Monias)
Moosebar
Loon River
Gething
Dunlevy
Cadomin
Upper Nikanassin
Mountain Park
Luscar
Cadomin
Upper Nikanassin
Blairmore
Shale
Stockmen's Sand
Shale
McDougall-Segur Sand
Shale
Home Sand
Shale
Dalhousie Sand
Upper Kootenay
Lower Kootenay
Brown Sand
Sand And Shale
Joli Fou
Upper
Middle
Glauconitic Sand
Ostracod Zone
Basal Sand
Grand Rapids
Clearwater
McMurray
Manville
Colony Sand
O'Sullivan
Barra-daile
Sparky Sand
Tovell
Islay
Lloydminster Sand
Cummings
Dina
Bow Island Sand
Shale
Second Bow Island Sand
Shale
Third Bow Island Sand
Shale
Basal Alberta Sand
Blairmore
Princess Sand (Sunburst)
Ellis
JURASSIC
UPPER
MIDDLE
LOWER
Lower Nikanassin
Lower Nikanassin
Lower Kootenay
Fernie
Fernie
Fernie
Nordegg
Nordegg
Nordegg
TRIASSIC
UPPER
MIDDLE
LOWER
Schooler Creek
Spray River
Spray River
Whitehorse
Sulphur Mountain
Spray River
Whitehorse
Sulphur Mountain
PERMIAN
PENNSYLVANIAN
Perma-Pennsylvanian (Undivided)
Rocky Mountain
Rocky Mountain
Norquay Mountain
Upper Dense Zone
TER

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FOOTHILLS
ROCKY MOUNTAIN
BELT
FRONT RANGE
EDMONTON
CALGARY

FIG. 1 — MAP OF GAS AND OIL FIELDS AND PROSPECTS, PROVINCE OF ALBERTA, CANADA.

No.	Census Division	Discovery Date	Field or Prospect Name
1	(11)	1950	Acheson
2	(10)	1950	Akaxu
3	(3)	1083	Alderson
4	(4)	1948	Alderyde
5	(7)	1951	Alliance
			Amisk Lake (see Boyle-Mustang-Amisk Lake)
6	(16)	1951	Amisk
7	(3)	1951	Antelope Hills
8	(3)	1963	Armelgra
9	(8)	1948	Armena
10	(13)	1949	Ashmont
11	(16)	1943	Athabasca
12	(16)	1932	Athadome
13	(5)	1939	Atlee
14	(3)	1948	Bantry-Tilley
15	(1)	1950	Barnwell
16	(16)	1948	Barrhead
17	(16)	1950	Barrhead, North
18	(4)	1950	Barons
19	(8)	1950	Bashaw
20	(3)	1947	Bassano
21	(3)	1918	Bassano Townsite
22	(9)	1948	Battle Lake
23	(10)	1937	Battlemen
24	(7)	1946	Baxter Lake
25	(9)	1916	Bearberry
26	(11)	1946	Beaverhill Lake
27	(16)	1951	Bellay
28	(11)	1951	Big Lake
29	(8)	1950	Big Valley
30	(8)	1951	Big Valley, South
			Birch Lake (included in Viking-Kinsella)
31	(1)	1944	Black Butte
32	(4)	1949	Black Diamond
			Blackfoot (see Lloydminster)
33	(14)	1949	Bollegor Lake
34	(11)	1949	Bon Accord
35	(13)	1948	Bonnyville
36	(16)	1948	Borradaile
37	(1)	1909	Bow Island
			Boyle (see Boyle-Mustang-Amisk Lake)
38	(14)	1949	Boyle-Mustang-Amisk Lake
39	(14)	1950	Brandt
40	(9)	1937	Brazeau
41	(11)	1951	Bremner
42	(3)	1910	Bronks
43	(3)	1946	Bronks, Northeast
44	(10)	1950	Brosseau
45	(7)	1946	Bruce
46	(7)	1950	Bulwark
47	(11)	1949	Calahoo
			Calmar (included in Leduc-Woodbend)
48	(11)	1949	Campbell
49	(8)	1951	Camrose, North
50	(8)	1947	Camrose, South
51	(1)	1947	Canal Creek
52	(13)	1949	Canard
53	(8)	1951	Caprona
54	(11)	1950	Carrot
55	(8)	1949	Casagrama
56	(7)	1916	Castor
57	(5)	1949	Cessford
			Cessford-Delia
			Bantrymah-Amerada
58	(11)	1948	Cherhill
59	(1)	1945	Chin Coulee
60	(5)	1951	Chinook
61	(12)	1949	Chip Lake
62	(16)	1949	Chisholm
63	(4)	1950	Claresholm
			Claymore (included in Viking-Kinsella)
			Clearwater (now separated from Ram River)
64	(9)	1938	Clearwater
65	(14)	1948	Clyde
66	(12)	1945	Coalinger
67	(1)	1944	Conrad
68	(11)	1949	Coohing Lake
69	(7)	1949	Coronation
70	(14)	1950	Cousach
71	(3)	1950	Countess
72	(5)	1949	Craigmyle
73	(6)	1951	Cremona
74	(5)	1945	Crossfield
75	(14)	1948	Dapp
76	(14)	1949	Darling
77	(1)	1926	Dead Horse Coulee
78	(11)	1946	Deadmon Lake
79	(2)	1936	Del Bonita
80	(11)	1949	Del Rio

No.	Census Division	Discovery Date	Field or Prospect Name
81	(8)	1946	Delburne
82	(5)	1949	Delia
83	(10)	1951	Delph
84	(5)	1951	Dewdrop Lake
85	(4)	1947	Dr[illegible]
86	(10)	1925	Duac
87	(10)	1929	Duac, North
88	(3)	1917	Drowning Ford
89	(5)	1950	Drumheller
90	(8)	1950	Dubamel
91	(1)	1947	Dunmore
92	(16)	1951	Dunvegan
			Duranna (see Lloydminster)
93	(10)	1946	Duverney
94	(1)	1928	Eagle Butte
95	(17)	1951	East Wabiskaw
96	(7)	1947	Edgerton
97	(13)	1946	Elk Point Alberta Salt Plant
98	(13)	1948	Elk Point Townsite
99	(11)	1950	Ellerslie
100	(8)	1950	Elnora
101	(3)	1946	Empress
102	(1)	1927	Erickson Coulee
103	(8)	1947	Ermonenkin
104	(8)	1950	Erskine
105	(1)	1951	Etzhorn
106	(11)	1949	Excelsior
			Eyot (included in Leduc-Woodbend)
			Fabyan (included in Viking-Kinsella)
107	(15)	1950	Falher
108	(14)	1949	Figure Lake
			Flint (see Duhamel)
109	(1)		Foremost
		1923	
110	(13)	1949	Fork Lake
111	(14)	1950	Fort Assiniboine
112	(11)	1949	Fort Saskatchewan
113	(5)	1950	Forgo
114	(8)	1950	Gadsby
115	(11)	1949	Gainford
116	(11)	1948	Gilbert
117	(11)	1950	Glen Park
118	(11)	1949	Golden Spike
119	(1)	1946	Grassy Lake
120	(11)	1949	Greenbush
121	(16)	1950	Grimshaw
122	(14)	1950	Grosmont
123	(15)	1950	Grouard
124	(10)	1950	Hairy Hill
			Halfway Lake (see Jeffrey-Halfway Lake)
125	(16)	1951	Hamelin Creek
126	(5)	1947	Hanna
127	(1)	1945	Hay Lake
			Homestead (included in Baxter Lake)
128	(14)	1949	Hondo
129	(17)	1951	Horse Hills
130	(17)	1917	Horse River
131	(15)	1949	Hylo
			Irma (included in Viking-Kinsella)
132	(14)	1949	Jarrow
133	(14)	1950	Jeffrey-Halfway Lake
134	(5)	1942	Jenner
135	(11)	1949	Joseph Lake
136	(6)	1944	Jumpingpound
137	(6)	1929	Jumpingpound Townsite
138	(1)	1949	Juno
			Kavanagh (Formerly included in Leduc-Woodbend. Now applied to a new area of production)
139	(11)	1951	Kavanagh
140	(4)	1933	Kehe
141	(6)	1947	Keystone
			Kinsella (see Viking-Kinsella)
			Kitscoty (see Lloydminster)
142	(3)	1946	Kitsim
143	(13)	1949	Lac la Biche
144	(8)	1950	Leahurst
145	(11)	1947	Leduc-Woodbend
146	(14)	1947	Legal-Morinville
			Cardiff-Morinville
			Legal-Waybrook
			Manawan Lake
			Legal (see Legal-Morinville)
147	(17)	1927	Lesser Slave Lake

No.	Census Division	Discovery Date	Field or Prospect Name
148	(4)	1932	Lethbridge
149	(14)	1949	Lily
150	(14)	1951	Lonarca
151	(11)	1950	Lusburn
152	(15)	1951	Little Smoky Lake
153	(10)	1934	Lloydminster
			Long Island (see Manawan Lake)
154	(7)	1950	Loyalist
155	(2)	1935	Lundbreck
156	(11)	1949	McFadden Lake
157	(10)	1950	McLaughlin
			McLeod (included in Leduc-Woodbend)
158	(11)	1951	Majeau Lake
			Manawan Lake (see Legal-Morinville)
159	(1)	1947	Manyberries
			Many Island (included in Medicine Hat)
160	(14)	1950	Meadowbrook
161	(3)	1950	Medicine Hat
162	(17)	1951	Meridian
163	(11)	1949	Midland
164	(11)	1947	Millet
165	(1)	1928	Moore
166	(6)	1935	Mount Mountain
			Morinville (see Cardiff-Morinville)
167	(12)	1948	Mosbeg
			Mustang (see Boyle-Mustang-Amisk Lake)
168	(11)	1951	Naman
169	(6)	1951	Nargolea
170	(14)	1950	Nestow
171	(11)	1949	Nisku
172	(11)	1949	Nisku, South
			Nordegg (see Brazeau)
173	(15)	1950	Normandville
174	(16)	1951	North Tangent
175	(8)	1949	Northview
			Nose Creek (see Crossfield)
176	(11)	1951	Octave
			Okalta (included in Leduc-Woodbend)
177	(4)	1951	Oldman
178	(11)	1950	Oliver
179	(11)	1951	Oliver Lake
180	(11)	1949	Onoway
181	(9)	1962	Open
			Pakowki (see Provost d'Orcilla)
182	(3)	1945	Patricia
183	(16)	1937	Peace River
184	(6)	1945	Pekisko
185	(17)	1950	Pelican Lake
186	(17)	1897	Pelican Rapids
187	(1)	1946	Pendant d'Oreille
188	(14)	1949	Picardville-Westlock
			Picardville
			Westlock
189	(2)	1948	Pincher Creek
190	(14)	1949	Pine Creek
191	(8)	1951	Pine Lake
192	(1)	1932	Pinhorn
193	(8)	1948	Pipestone Creek
194	(10)	1949	Plain Lake
195	(8)	1916	Ponoka
196	(16)	1941	Ponce Coupe
197	(3)	1948	Princess
198	(1)	1947	Prospy
199	(7)	1948	Provost
200	(3)	1950	Rainy Hills
201	(3)	1951	Rainy Hills, South
202	(9)	1962	Ram River
		1950	Rasbury (included in Viking-Kinsella)
203	(3)		Ranger
			Redcliff (see Medicine Hat)
204	(1)	1929	Red Coulee
205	(14)	1948	Redwater
			Rolestone (included in Dina)
206	(3)	1913	Riverbank
207	(14)	1949	Rochester
208	(3)	1950	Rolling Hills
209	(8)	1949	Rosecan
210	(8)	1950	Rosedale
211	(11)	1950	Round Hill
212	(10)	1950	Royal Park
213	(16)	1950	Royce

No.	Census Division	Discovery Date	Field or Prospect Name
214	(11)	1950	Sarepta
215	(8)	1949	Scollard
216	(7)	1951	Scurvi Lake
217	(5)	1950	Sibbald
			Silverdale (see Lloydminster)
218	(10)	1950	Skaro
219	(1)	1927	Shaft
220	(1)	1947	South Coulee
			South Calmar (included in Leduc-Woodbend)
			Sparky (see Oyen)
221	(13)	1950	Spedden
222	(8)	1948	Spotted Creek
223	(2)	1950	Spring Coulee
224	(14)	1949	Sprucefield
225	(11)	1951	Spruce Grove
226	(13)	1947	St. Paul
227	(5)	1950	Stanmore
228	(8)	1949	Stettler
229	(3)	1939	Stevenville
230	(9)	1948	Stolberg
231	(3)	1951	Suffield
232	(4)	1943	Sullivan Creek
233	(11)	1950	Sunnybrook
			Sunnymah (included in Ceasler-4 Sylvan Glen (see Bellaqor Lake)
234	(7)	1940	Taber, East
235	(1)	1944	Taber, South
236	(1)	1946	Taber, Southeast
237	(1)	1937	Taber, West
238	(14)	1949	Tawatinaw
239	(11)	1948	Tellerdville
240	(11)	1950	Terra
241	(11)	1951	Terra, North
242	(11)	1951	Terra, West
243	(3)	1948	Tide Lake
			Tilley (see Bantry-Tilley)
244	(3)	1947	Tilley, West
245	(10)	1948	Tolleid
246	(3)	1945	Toronto
247	(13)	1950	Touchwood Lake
248	(3)	1948	Turin
249	(4)	1914	Turner Valley
250	(2)	1932	Twin River
251	(10)	1933	Two Hills
252	(7)	1945	Vale Dome
253	(15)	1950	Valleyview
254	(10)	1913	Vegreville Townsite
255	(1)	1928	Verdigris Coulee
256	(10)	1939	Vermilion
257	(10)	1948	Vermilion, North
258	(5)	1951	Vernon
259	(10)	1910	Viking-Kinsella
260	(8)	1948	Viking, West
			Volmer (included in Cardiff-Morinville)
			Wabamun (see Tellerdville)
261	(7)	1922	Wainwright
262	(7)	1929	Wainwright Townsite
			Warner (included in Hanna)
			Waybrook (see Legal-Waybrook)
			West Edmonton (included in Acheson)
263	(10)	1950	West Wabasbaw
			Westlock (see Picardville-Westlock)
264	(8)	1913	Wetaskiwin
265	(5)	1949	Wheat King
266	(10)	1950	Whitelaw
267	(11)	1949	Whitemud
268	(11)	1949	Whitemud, Southwest
269	(10)	1949	Willingdon
270	(8)	1951	Wimborne
271	(1)	1949	Winnifred, North
272	(1)	1949	Winnifred, South
273	(11)	1947	Winard Lake
274	(11)	1950	Tehaw
275	(1)	1929	Yellow Lake
276	(5)	1950	Youngstown
277	(5)	1950	Youngstown Townsite

FIG. 1A — LIST OF GAS AND OIL FIELDS AND PROSPECTS AS OF AUG. 1, 1951, PROVINCE OF ALBERTA, CANADA.

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AREAS				POUCE COUPE PEACE RIVER AND PINE RIVER	NORTHERN ALBERTA FOOTHILLS	SOUTHERN ALBERTA FOOTHILLS	CENTRAL ALBERTA	ALBERTA PLAINS		
								NORTHEASTERN	EAST CENTRAL	SOUTHEASTERN
APPROXIMATE CENSUS DIVISION AREAS				16 & W/2 15	W/2 15,12,9	W/2 6,4,2	E/2 14 ALL OF 11 & 8 E/2 5	E/2 17 & N/2 13	E/2 13 ALL OF 10 & 7	5,3,1 & E/2 6,4,2
CENOZOIC	QUATERNARY	RECENT								
		PLEISTOCENE								
	TERTIARY	PLIOCENE								
		MIOCENE								
		OLIGOCENE								
		EOCENE								
		PALEOCENE		Present	Present	Porcupine Hills	Paskapoo			
MESOZOIC	CRETACEOUS	UPPER	MONTANA GROUP			St Mary River	Edmonton			
				Wapiti	Brazeau	Bearpaw	Bearpaw			Bearpaw
									Oldman	Oldman
									Birch Lake	
						Belly River	Belly River	Montana Shale	Grizzly Bear	Foremost
									Ribstone Creek	
										Upper Pakowki
				Smoky River		Highwood Sand	Lea Park		Lea Park	Pakowki
				Wapiabi	Wapiabi	Shale				Milk River
			COLORADO GROUP				First White Specks			Shale
				Cardium Sand	Cardium Sand	Cardium Sand	Shale			Medicine Hat Sand
				Kaskapau	Blackstone	Blackstone	Second White Specks			
				Dunvegan			Colorado Shale	Colorado Shale	Colorado Shale	Colorado Shale
				Cruiser		Shale	Shale			Shale
				Shaftesbury						
				Fish Scale Sand		Alberta Shale	Fish Scale Sand			Fish Scale Sand
				Goodrich		Jumpingpound Sand	Shale			
										Shale
				Basal Grit Zone			Viking Sand	Pelican Sand	Viking Sand	First Bow Island Sand
				Fort St John Hasler	Mountain Park	Shale				Shale
										Second Bow Island Sand
										Shale
							Joli Fou	Joli Fou	Joli Fou	Third Bow Island Sand
										Shale
										Basal Alberta Sand
		LOWER	BLAIRMORE GROUP	Continental Sand		Stockmen's Sand			Colony Sand	
				Cadotte Sand						
				Harmon Shale		Shale			O'Sullivan	
				Peace River Commotion		McDougall-Segur Sand	Upper	Grand Rapids	Bernadale / Sparky Sand	
				Notikewin Sand						
				Farrell Shale		Shale			Tovell	Blairmore
				Gates Sand (Monias)					Islay / Lloydminster Sand	
				Moosebar	Loon River		Middle	Clearwater	Cummings	
						Home Sand	Glauconitic Sand			Princess Sand ("Sunburst")
						Shale	Ostracod Zone			
				Bullhead Gething	Luscar		Basal Sand	McMurray	Dina	
				Dunlevy	Cadomin	Dalhousie Sand				
					Upper Nikanassin	Upper Kootenay				

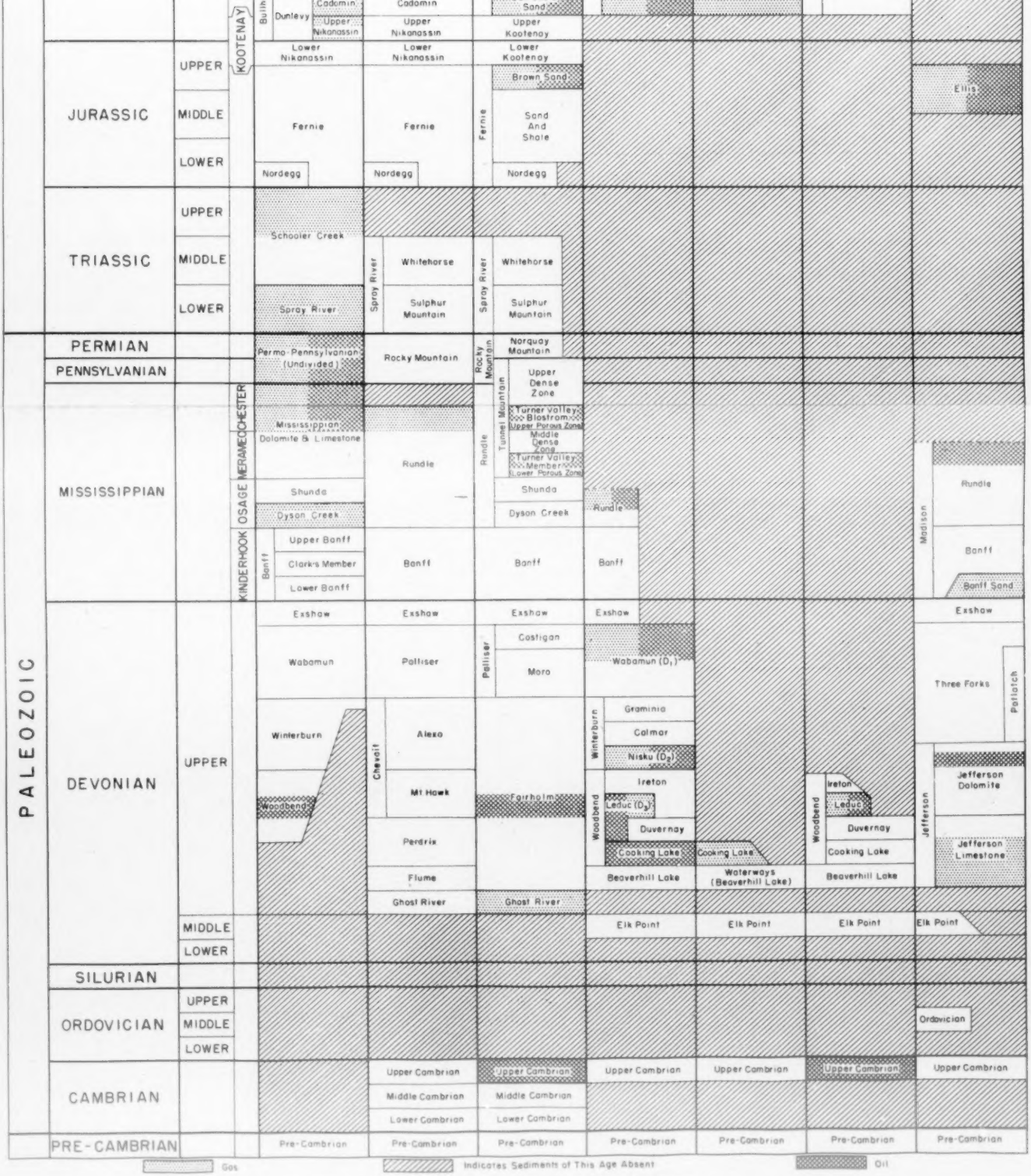

FIG. 2 — GENERALIZED COLUMNAR SECTIONS, PROVINCE OF ALBERTA.

the biohermal reef oil accumulations. Type examples of composite reservoirs appear to be those in the Cessford and Legal-Morinville Fields, and the biostromal reef oil accumulations.

Available data suggest that composite reservoirs are the most numerous, but it is possible that such a conclusion is more apparent than real because of insufficient data to determine the dominant control. This is particularly true of the newly discovered gas accumulations in the Peace River area.

In a broad generalization, the Devonian Leduc (D_3) reservoirs are stratigraphically controlled and Nisku (D_2) reservoirs are composite in nature. Mississippian reservoirs are dominated by structure. The Permo-Pennsylvanian, Triassic, and Jurassic reservoirs are composite, with likelihood of dominant stratigraphic control. The Cretaceous reservoirs are composite, but most of the major gas accumulations seem to be dominated by at least some type of stratigraphic variation.

Certain broad generalizations can be made with respect to the stratigraphic distribution of the recovery mechanisms of the various major gas accumulations in Alberta. The Devonian reservoirs appear to show appreciable evidence of some degree of waterdrive, but the Mississippian reservoirs probably will not have appreciable waterdrive. The Cretaceous accumulations are dominated by the depletion type recovery mechanism as borne out by experience to date.

Table II — Classification of Fields and Prospects by Types of Gas as of Jan. 1, 1952

	Proved	Semi-Proved	Others	Total
Non-Associated				
Producing	22			
Shut-in	39			
Potential	35			
Prospect	34			
Limited Prospect		101		
Farm Wells			6	
Gas Storage			1	
Abandoned			4	
Subtotal	130	101	11	242
Associated and Dissolved				
Producing	41			
Shut-in	11			
Potential	4			
Prospect	1			
Limited Prospect		12		
Abandoned			5	
Subtotal	57	12	5	74
GRAND TOTAL	187	113	16	316

Notes:
Potential, refers to fields with gas zones cased off pending development of markets for the gas.
Prospect, refers to areas in which testing has established the presence of measurable gas in quantity, but all test wells were abandoned.
Limited Prospect, refers to an area in which testing has established some measurable gas, but the occurrence is apparently subcommercial to date.

HISTORY OF DEVELOPMENT

The initial discovery of gas in the province of Alberta was in the Alderson well in 1883. The first commercial gas field was found at Medicine Hat in 1890, and the first commercial oil well was completed in Turner Valley in 1914. During the 68 years, between 1883 and 1952, drilling has developed measurable gas volumes in at least 316 localities. As reflected by Table I, only 27 per cent of these localities can be credited to the first 62 years of development. With the discovery of the Leduc-Woodbend Field in the 64th year, 1947, competitive drilling was so accelerated that 70 per cent of Alberta's discoveries have been made since 1947. Even more significant, 58 per cent have been found in the last three years, and, due in part to the activity resulting from applications for permits to export gas from Alberta, 24 per cent were found during 1951.

Table I — Number of Oil and Gas Fields and Prospects Completed Annually in the Province of Alberta Between 1883 and 1952

Discovery Year	No. Completed	Name of Principal Discovery	Discovery Year	No. Completed	Name of Principal Discovery
1883	1	Alderson	1935	2	
1890	1	Medicine Hat	1936	1	
1897	1		1937	3	
1909	1	Bow Island	1938	1	
1910	1	Brooks	1939	4	Steveville
1913	4		1940	4	Princess
1914	5	Turner Valley*	1941	1	
		Viking-Kinsella	1942	4	
1916	3	Peace River	1943	2	
1917	2		1944	6	Jumping Pound
1918	1		1945	7	
1920	1		1946	14	Pendant d'Oreille
1923	3	Foremost	1947	17	Leduc-Woodbend
1924	1		1948	17	Pincher Creek
1925	2				Redwater
1926	2				
1927	3		1949	53	Cessford
1928	4				Golden Spike
1929	3		1950	57	Acheson
1930	3				Whitelaw
1932	4		1951	74	Bonnie Glen
1933	2				Hamelin Creek
1934	1	Lloydminster			Wizard Lake
			TOTAL	316	

*Mesozoic oil was discovered in Turner Valley in 1914. The Turner Valley Madison gas cap was discovered in 1924, and the Madison oil band in 1936.

Table II illustrates that 77 per cent of the localities showing measurable volumes of gas appear to be non-associated in character and only 23 per cent associated with oil accumulation. While Alberta has only 22 producing non-associated gas fields and 41 producing oil fields which contain associated and/or dissolved gas reserves, it is significant that 187 localities, or 60 per cent, are presently capable of gas production if a pipeline outlet were available. In addition, there are 113 limited gas prospects (*i.e.*, localities in which measurable gas has been found but the test wells have been abandoned because the small amount of gas developed has only local or farm use) which, with future drilling, might yield commercial volumes of gas.

Table III indicates that gas has been found in 29 reservoirs of different stratigraphic age. Of the presently known reservoirs in the province, 63 per cent are found in sediments of Cretaceous age, and 17 per cent in Devonian sediments. A commercially significant feature of the future of Alberta gas production is the wide distribution of its gas reservoirs throughout the geologic column.

Finally, it is important to note that the majority of these 316 localities of measurable gas have been discovered incidental to the search for oil. Since permission to remove gas from the province in long distance transmission lines has yet to be granted, there is little incentive to develop gas reserves beyond a point sufficient to serve the existing local gas demand. When, and if, permission to export gas is given, and wells are drilled in search of gas, the rate of gas discovery should accelerate, and areas where gas has been discovered will be

Table III — Summary List of Fields and Prospects in the Province of Alberta

Classified According to Their Respective Reservoirs and Arranged in Approximate Stratigraphic Order as of Jan. 1, 1952

	Reservoirs	No. of Fields or Prospects Showing Measurable Gas in Each Reservoir		
	Cretaceous	220		
	Upper Cretaceous		20	
1.	Upper Cretaceous sand (Undivided)			1
2.	Paskapoo sand			2
3.	Edmonton sand			2
4.	Belly River sand			10
5.	Lea Park-Pakowki sand			3
6.	Milk River sands			8
7.	Medicine Hat sands			2
8.	Colorado sands			9
9.	Cardium sand			1
10.	Fish Scale sand			1
	Lower Cretaceous		200	
11.	Lower Cretaceous sands (Undivided)			22
12.	Pelican-Viking-Bow Island sands			132
13.	Basal Alberta sand			8
14.	Blairmore-Grand Rapids sands			165
15.	Nikanassin sands			13
16.	Jurassic	14		
17.	Triassic	5		
18.	Permo-Pennsylvanian	5		
	Mississippian	43		
19.	Mississippian Dolomite (Undivided)		3	
20.	Chester Dolomite		2	
21.	Madison-Rundle Dolomite		38	
	Devonian	60		
22.	Devonian Dolomite (Undivided)		4	
23.	Wabamum (D_3) Dolomite		19	
24.	Nisku (D_2)-Jefferson Dolomite		31	
25.	Leduc (D_2) Dolomite		17	
26.	Cooking Lake Dolomite		6	
27.	Beaverhill Lake Dolomite		1	
28.	Ghost River Dolomite and sand		3	
29.	Cambrian	2		

re-activated. This has been the experience of the oil and gas industry in other areas which have been actively explored to meet an increasing market demand.

NATURAL GAS RESERVES

Estimation of Reserves

The reserve estimates presented were calculated using the volumetric and/or pressure decline methods, depending upon the suitability of the available data.

Wherever possible, all pertinent wells and reservoir data, including drillers' logs, sample logs, core analyses and core descriptions, electrical and gamma ray-neutron logs, drill stem tests, flow tests, pressure and production histories, and reservoir fluid analyses, were used in preparing the estimates. Structural maps, isopachous and/or isobaric maps, and cross sections were utilized in determining the areal extent and volume of the reservoirs in the great majority of the fields considered.

These basic geological and engineering data served as bases for exercising judgment in appraising both the extent of reservoirs and the economic recovery of gas from such reservoirs.

The reduction of the volumes of gas in place to recoverable reserves available for sale at the wellhead was carefully considered, both with respect to reservoir losses and to surface losses. Reference is made to "remaining gas in place at terminal pressure, or at terminal conditions" in preference to "abandonment pressure" in view of the profound effect of economics, years hence, upon the actual abandonment pressure.

Considerable volumes of gas will be produced from all the reservoirs after the terminal conditions are reached, some for long distance transportation, but largely for local uses.

Surface losses, primarily field and fuel uses, including fuel for compression and shrinkage, have been deducted in arriving at the estimated recoverable gas available for sale. Actual physical waste of gas probably will become an almost negligible quantity in future years when the value of natural gas is realized fully and is reflected in adequate wellhead prices.

Classification of Reserves

Reserve estimates have been classified in three categories according to the quality of the reserves, the limitations of the data, and the assumptions made from those data in arriving at the estimates. In many instances, it is not possible to segregate reserves into these classifications with equal reasoning because of the wide variations in the types of structures, reservoirs, and in the basic data. The equality with which these divisions are made, therefore becomes subject primarily to the judgment of the appraiser.

Proved Reserves — Reserves proved for oil or gas production in a given reservoir by actual well tests, either in the cased hole or by definitive open hole drill stem tests, are classified as proved reserves. These reserves are defined areally by reasonable geological interpretation of structure and known continuity of oil and/or gas-saturated reservoir material above limiting water saturation.

Probable Reserves — These reserves, considered as essentially proved or capable of being proved, are defined by less direct well control but are based again upon evidence of producible gas or oil within the limits of a structure or reservoir above inferred or known water saturation.

Possible Reserves — This category is similarly determined but may be based largely upon electrical log interpretation or widespread evidence of commercial gas saturation defined by widely spaced test wells. It may also include areas of geophysical anomaly that are immediately adjacent to proved productive areas of like geophysical character.

Tabulation of Natural Gas Reserves

There are 24 major fields in Alberta, each of which has a recoverable reserve in excess of 100 billion cu ft of gas, on a proved, probable, and possible basis. These 24 fields account for 79 per cent of the total provincial gas reserve, which means that the major reserves as now known are concentrated in seven per cent of the 316 localities of measurable gas. Only six fields had initially recoverable reserves in excess of one trillion cu ft. Pertinent data on these six fields are as follows:

Field	Discovery Date	Principal Reservoir	Approx. No. of Wells Drilled in Field	Estimated Initially Recoverable Gas to Terminal Pressure (Proved and Probable) (MMcf)
Pincher Creek	1948	Mississippian	5	2,204,729
Turner Valley	1914	Mississippian	620	2,130,055
Leduc-Woodbend	1947	Devonian	925	1,349,322
Medicine Hat	1890	Upper Cretaceous	120	1,127,477
Cessford	1949	Lower Cretaceous	25	1,092,667
Viking-Kinsella	1914	Lower Cretaceous	160	1,015,217

Table IV summarizes the natural gas reserves of the province of Alberta, Canada, as of Jan. 1, 1952, in categories of estimated recoverable gas reserves to terminal pressure and estimated gas available for sale. The estimated proved and probable recoverable reserve of the 104 fields studied is 1,687,114 million cu ft and the volume of gas available for sale from these fields is 9,440,283 million cu ft after deduction of approximately 30 per cent of the recoverable gas for surface losses and field or pipeline uses. A tentative estimate for the total provincial proved, probable, and possible recoverable gas reserve of the 187 localities capable of gas production is 16,146,835 million cu ft.

PRODUCING REGIONS

The following discussion of producing regions is grouped into four areas, namely, the Foothills Belt, the Central Alberta Plains, the Southeastern Alberta Plains, and the Peace River Area. Examples of type fields are discussed for each area. Their descriptions include a short historical account, major details of structure, and type of productive reservoir.

Alberta Foothills Belt

The discovery, in 1924, of large volumes of Rundle gas in the Turner Valley Field gave rise to exploratory drilling programs in the Foothills Belt. The search for oil and gas has varied in intensity because of high exploration costs resulting from rugged terrain and depth to prospective pay zones.

Large accumulations of non-associated gas have been found at Pincher Creek and Jumping Pound. It seems reasonable that there should be other accumulations on known structures in the Foothills. Recently, a drilling program has been commenced at Winchell Coulee, and the Sullivan Creek and Brazeau prospects have been reactivated. The Brazeau structure contains a known commercial gas accumulation in Lower Cretaceous sands and in the Madison limestone, and two wells drilled over a decade ago reported flows up to 10 million cu ft of gas per day.

These folded and overthrust fault structures of the Foothills Belt are large elongated structures paralleling the Front Range of the Rocky Mountains. They represent an area in which there are possibilities of large, high pressure gas accumulations. Additional exploratory drilling should add major reserves to the province.

Pincher Creek Field

The Pincher Creek structure is a representative Foothills gas field since it is a strongly asymmetric fold of the Rundle limestone in a complex of thrust sheets. The discovery resulted from highly competent geological and geophysical work by the staff of Canadian Gulf Oil Co. The extremities of the structure are not well defined and may extend beyond the limits as currently estimated. The eastern limit of the field is a low angle thrust fault and the western limit is a gas-water contact at an estimated subsea elevation of 8,200 ft. The estimated gas reserve recoverable to a terminal reservoir pressure of 700 psia is 2,292,465 million cu ft, representing 1,543,310 million cu ft of gas available for sale after deduction of estimated field and fuel uses and shrinkage losses.

Central Alberta Plains

Accumulations of natural gas in the Central Plains of Alberta are of the non-associated, associated, and dissolved types. Gas occurs in Lower Cretaceous sands and Devonian carbonates over a large area, ranging from Edmonton on the west to the border of Saskatchewan on the east, and from Lac la Biche on the north to the vicinity of Drumheller and Hanna on the south.

The development and growth of great coral reefs in the Upper Devonian account for a considerable number of these gas accumulations. Their development was accompanied by rapid lateral facies changes. The reefs are normally at least 1,000 ft in thickness and frequently contain water almost to their tops. Throughout the Central Plains, Upper Devonian is generally overlain by Lower Cretaceous.

Major oil discoveries in the Devonian Nisku (D_3) and Leduc (D_2) carbonates account for a large portion of the natural gas reserves in this area. Most of the Devonian and Lower Cretaceous accumulations are due to combined stratigraphic and structural conditions.

Leduc-Woodbend Field

In 1947 Imperial Oil Co. drilled a seismic anomaly at Leduc as a part of a regional stratigraphic test exploratory program. Originally scheduled as a deep pre-Cambrian test, it unexpectedly found oil in Nisku (D_3) dolomite, and it became the first commercial Devonian oil completion in the central part of the province. A second well successfully established the presence of biohermal reef oil in the subjacent Leduc (D_2) dolomite. Together these became the most important completions since the discovery of the Rundle reservoir in the Turner Valley Field in 1924, and was the beginning of Alberta's increasing importance as an oil and gas province. Their drilling initiated the development of what is now the Leduc-Woodbend Field which includes some 925 wells. The reef has been completely penetrated, and one deep test ends in Elk Point evaporites of Middle Devonian age. In addition to Devonian oil, a large Lower Cretaceous non-associated gas reserve has been established.

The Leduc-Woodbend Field is a large biohermal reef over which superjacent Devonian and Cretaceous sediments have been arched. Regional dip is to the southwest, and the apex of the structure lies almost at its northeast end. The gas-water interfaces in the Cretaceous sands rise to the northeast, while the Devonian water tables essentially are flat.

The Viking sand of Lower Cretaceous age has one producing gas well. Normally, drill stem tests are not taken in the Viking sand, but the few which do exist illustrate that this reservoir is capable of limited commercial gas production throughout the structurally higher portions of the field.

The Blairmore sands in the Leduc-Woodbend Field have multiple gas pays. More than 100 drill stem tests reflect daily gas volumes ranging from 1 to 10 million cu ft. The principal gas reservoir occurs in the Basal Cretaceous sand. One Lower Cretaceous sand in the Woodbend area of the field contains oil, but the area of oil saturation is limited.

An occasional drill stem test is taken in the Wabamun (D_1) dolomite and a few of these demonstrate appreciable volumes of oil and gas, but no test has been commercially successful. The Nisku (D_3) dolomite, primarily an oil zone, contains the major dissolved gas reserve in the province. The northeast

Table IV — Summary of Natural Gas Reserves in the Province of Alberta, Canada, as of Jan. 1, 1952

(All Gas Volumes in MMcf at Base Pressure of 14.4 psia and 60°F)

Field Name (1)	Census Division (2)	Discovery Date (3)	Reservoir (4)	Depth (5)	Type of Gas (6)	Estimated Recoverable Reserves: Proved and Probable (7)	Proved Probable and Possible (8)	Est. Gas Available for Sale (9)
Pincher Creek	2	1948	Rundle Limestone	11,700	Non-Associated	2,204,115	2,291,850	1,542,880
Leduc-Woodbend	11	1947	Viking Sand	3,450	Non-Associated	6,888	18,083	6,372
		1947	Upper Blairmore Sands	3,800	Non-Associated	8,828	24,758	8,153
		1948	Lower Blairmore Sands	4,000	Associated	....	....	....
		1948	Lower Blairmore Sands	4,000	Dissolved	....	....	....
		1947	Lower Blairmore (Composite Sands)	4,200	Non-Associated	333,161	391,705	305,452
		1951	Wabamun (D_1) Dolomite	4,540	Dissolved	....	....	....
		1947	Nisku (D_2) Dolomite	5,000	Dissolved	286,760	299,677	229,408
		1947	Leduc (D_3) Dolomite	5,250	Associated	583,480	583,480	438,480
		1947	Leduc (D_3) Dolomite	5,400	Dissolved	107,455	85,964	85,964
Total						1,326,572	1,425,158	1,073,829
Cessford	5	1949	Viking Sand	2,800	Non-Associated	128,006	222,139	118,579
		1949	Upper Blairmore Sand	3,100	Non-Associated	594,073	670,325	550,989
		1950	Second Blairmore (Stray Sand)	2,910	Non-Associated	8,928	18,026	8,267
		1949	Princess (Sunburst) Sand	3,460	Non-Associated	361,660	418,602	313,901
		1951	Princess (Sunburst) Sand	3,350	Associated	....	....	....
		1951	Princess (Sunburst) Sand	3,356	Dissolved	....	....	....
Total						1,092,667	1,329,092	991,736
Medicine Hat	3	1890	Milk River Sand	800	Non-Associated	....	....	....
		1908	Medicine Hat Sand	1,075	Non-Associated	1,023,167	1,179,303	818,534
		1926	Bow Islands Sands	2,350	Non-Associated	....	....	....
		1926	Blairmore Sand	2,700	Non-Associated	....	....	....
		1926	Blairmore Sand	2,925	Non-Associated	....	....	....
		1926	Ellis Limestone	3,075	Dissolved	....	....	....
Total						1,023,167	1,179,303	818,534
Viking-Kinsella	10	1914	Viking Sand	2,100	Non-Associated	844,301	1,093,363	726,099
Jumping Pound	6	1944	Rundle Limestone	10,100	Non-Associated	715,860	849,193	536,895
Whitelaw	16	1950	Upper Nikanassin Sand	2,800	Non-Associated	179,291	203,363	166,712
		1950	Upper Triassic Sand	3,300	Non-Associated	408,512	420,367	379,555
		1950	Lower Triassic Sand	3,650	Non-Associated	11,289	15,984	10,454
		1950	Permo-Pennsylvanian Dolomite	3,880	Dissolved	....	....	....
Total						599,092	639,714	556,721
Turner Valley	4	1914	Mesozoic Sands	2,200	Non-Associated	....	....	....
		1914	Mesozoic Sands	to	Associated	....	....	....
		1914	Mesozoic Sands	5,500	Dissolved	....	....	....
		1924	Rundle Limestone	3,800	Associated	325,671	325,671	....
		1936	Rundle Limestone	9,150	Dissolved	228,420	228,420	....
Total						554,091	554,091	343,536
Princess	3	1940	Bow Island Sands	2,450	Non-Associated	10,485	189,267	9,721
		1945	Basal Alberta Sand	2,850	Non-Associated	117,809	146,957	109,023
		1940	Princess (Sunburst) Sand	3,250	Non-Associated	103,682	124,639	96,100
		1947	Madison Limestone	3,300	Associated	27,770	34,253	21,383
		1940	Madison Limestone	3,330	Dissolved	....	....	....
		1948	Jefferson Dolomite	3,930	Associated	23,297	23,297	17,939
		1944	Jefferson Dolomite	3,960	Dissolved	....	....	....
		1947	Cooking Lake Dolomite	4,845	Non-Associated	....	....	....
		1940	Beaverhill Lake Dolomite	5,130	Non-Associated	....	....	....
Total						283,043	518,413	254,166
Legal-Morinville	14	1947	Viking Sand	2,700	Non-Associated	21,480	26,317	19,688
		1947	Upper Blairmore Sand	2,965	Non-Associated	....	....	....
		1948	Blairmore Glauconitic Sand	3,380	Non-Associated	317,863	356,836	294,411
		1947	Basal Blairmore Sands	3,500	Non-Associated	....	....	....
		1949	Basal Blairmore Sand	3,670	Dissolved	....	....	....
Total						339,343	383,153	314,099
Pendant d'Oreille	1	1946	Bow Island Sands	2,100	Non-Associated	329,746	329,746	322,600
Provost	7	1946	Viking Sand	2,350	Non-Associated	123,837	151,523	113,167
		1946	Upper Blairmore Sand	2,450	Non-Associated	14,606	87,974	13,303
Total						138,443	239,497	126,470
Golden Spike	11	1949	Viking Sand	3,560	Non-Associated	2,986	5,054	2,759
		1949	Basal Blairmore "A" Sand	4,300	Non-Associated	24,198	28,675	22,357
		1949	Basal Blairmore "B" Sand	4,400	Non-Associated	14,742	28,600	13,637
		1949	Wabamun (D_1) Dolomite	4,500	Associated	25,048	27,005	22,293
		1951	Wabamun (D_1) Dolomite	4,600	Dissolved	....	....	....
		1950	Nisku (D_2) Dolomite	5,000	Dissolved	10,463	10,463	....
		1949	Leduc (D_3) Dolomite	5,350	Dissolved	118,221	118,221	....
		1949	Cooking Lake	5,900	Dissolved	13,564	13,564	....
Total						209,222	231,582	61,046

Table IV — (Continued)

Field Name (1)	Census Division (2)	Discovery Date (3)	Reservoir (4)	Depth (5)	Type of Gas (6)	Estimated Recoverable Reserves: Proved and Probable (7)	Proved Probable and Possible (8)	Est. Gas Available for Sale (9)
North Tangent	16	1951	Upper Peace River Sand	1,150	Non-Associated	26,644	33,486	24,721
		1950	Upper Nikanassin Sand	2,405	Non-Associated	75,528	100,623	70,091
		1951	Triassic Sand	2,840	Non-Associated	89,686	95,791	83,248
Total						191,858	229,900	178,060
Brooks Northeast	3	1948	Bow Island Sands	2,580	Non-Associated	18,560	74,815	17,261
		1948	Basal Alberta Sand	2,900	Non-Associated	67,970	90,192	63,212
		1946	Princess (Sunburst) Sand	3,265	Non-Associated	14,064	56,080	13,080
Total						100,594	221,087	93,553
Hanna	5	1949	Viking Sand	3,195	Non-Associated	22,054	83,069	20,391
		1949	Princess (Sunburst) Sand	3,720	Non-Associated	1,006	21,097	906
		1947	Madison Limestone	3,770	Non-Associated	19,031	57,018	17,047
Total						42,091	161,184	38,344
Steveville	3	1939	Bow Island Sand	2,500	Non-Associated	15,048	82,849	13,980
		1939	Basal Alberta Sand	2,750	Non-Associated	14,374	52,839	13,268
		1939	Princess (Sunburst) Sand	3,050	Non-Associated	12,573	21,907	11,620
Total						41,995	157,595	38,868
Acheson	11	1950	Viking Sand	3,300	Non-Associated	17,027	20,390	15,821
		1950	Blairmore Glauconitic Sand	3,800	Non-Associated	7,965	59,229	7,363
		1950	Basal Blairmore Sand	4,000	Non-Associated	30,266	54,292	28,102
		1950	Basal Blairmore Sand	3,960	Dissolved	....	....	....
		1951	Wabamun (D_1) Dolomite	4,320	Non-Associated	....	....	....
		1950	Nisku (D_2) Dolomite	4,700	Dissolved	1,322	1,322	925
		1950	Leduc (D_3) Dolomite	5,000	Dissolved	12,171	12,171	8,520
Total						68,751	147,404	60,731
Boyle-Mustang-Amisk Lake	14	1949	Pelican Sand	1,385	Non-Associated	....	....	....
		1949	Upper Grand Rapids Sand	1,610	Non-Associated	25,812	65,092	23,945
		1951	Middle Grand Rapids Sand	1,810	Non-Associated	8,256	15,151	7,626
		1951	Lower Grand Rapids Sand	1,890	Non-Associated	20,692	38,413	18,934
		1949	McMurray Sand	1,940	Non-Associated	7,500	10,744	6,960
		1949	Nisku (D_2) Dolomite	2,040	Non-Associated	11,626	16,171	10,716
Total						73,886	145,571	68,181
Sibbald	5	1950	Viking Sand	2,580	Non-Associated	54,808	138,693	50,759
		1950	Banff Sand	3,000	Non-Associated	....	....	....
Total						54,808	138,693	50,759
Castor	7	1914	Belly River Sand	1,430	Non-Associated	....	....	....
		1949	Viking Sand	3,140	Non-Associated	55,792	61,074	51,547
		1949	Lower Blairmore Sand	3,470	Non-Associated	63,014	73,161	58,371
		1950	Basal Blairmore Sand	3,550	Non-Associated	1,116	1,503	1,015
Total						119,922	135,738	110,933
Countess	3	1950	Bow Island Sand	2,950	Non-Associated	77,599	87,130	72,022
		1950	Bow Island Sands	3,050	Non-Associated	25,369	28,380	23,503
Total						102,968	115,510	95,525
Redwater	14	1949	Viking Sand	1,950	Non-Associated	15,943	17,755	15,315
		1948	Upper Blairmore Sand	2,100	Non-Associated	....	....	....
		1949	Middle Blairmore Sand	2,250	Non-Associated	....	....	....
		1948	Blairmore Glauconitic Sand	2,400	Non-Associated	2,615	4,149	2,463
		1948	Basal Blairmore Sand	2,550	Non-Associated	....	....	....
		1948	Leduc (D_3) Limestone	3,100	Dissolved	84,735	84,735	4,237
Total						103,293	106,639	22,015
Manyberries	1	1947	Bow Island Sands	2,600	Non-Associated	107,443	107,443	105,176
TOTAL RESERVE ESTIMATE FOR 24 MAJOR FIELDS						10,667,271	12,730,919	8,530,756
TOTAL RESERVE ESTIMATE FOR 80 MINOR FIELDS AND PROSPECTS						1,019,843	1,715,916	909,527
SUBTOTAL — (104 Fields and Prospects)						11,687,114	14,446,835	9,440,283
TENTATIVE RESERVE ESTIMATE FOR 83 ADDITIONAL LOCALITIES						....	1,700,000	....
GRAND TOTAL EST. PROVINCIAL RESERVES (187 Localities Capable of Gas Production)						11,687,114	16,146,835	9,440,283
SUBDIVISION OF RESERVES BY TYPE OF GAS (24 MAJOR FIELDS)								
NON-ASSOCIATED GAS RESERVES						8,818,894	10,861,185	7,358,071
ASSOCIATED GAS RESERVES						985,266	993,706	702,011
DISSOLVED GAS RESERVES						863,111	876,028	470,674
TOTAL GAS RESERVES						10,667,271	12,730,919	8,530,756

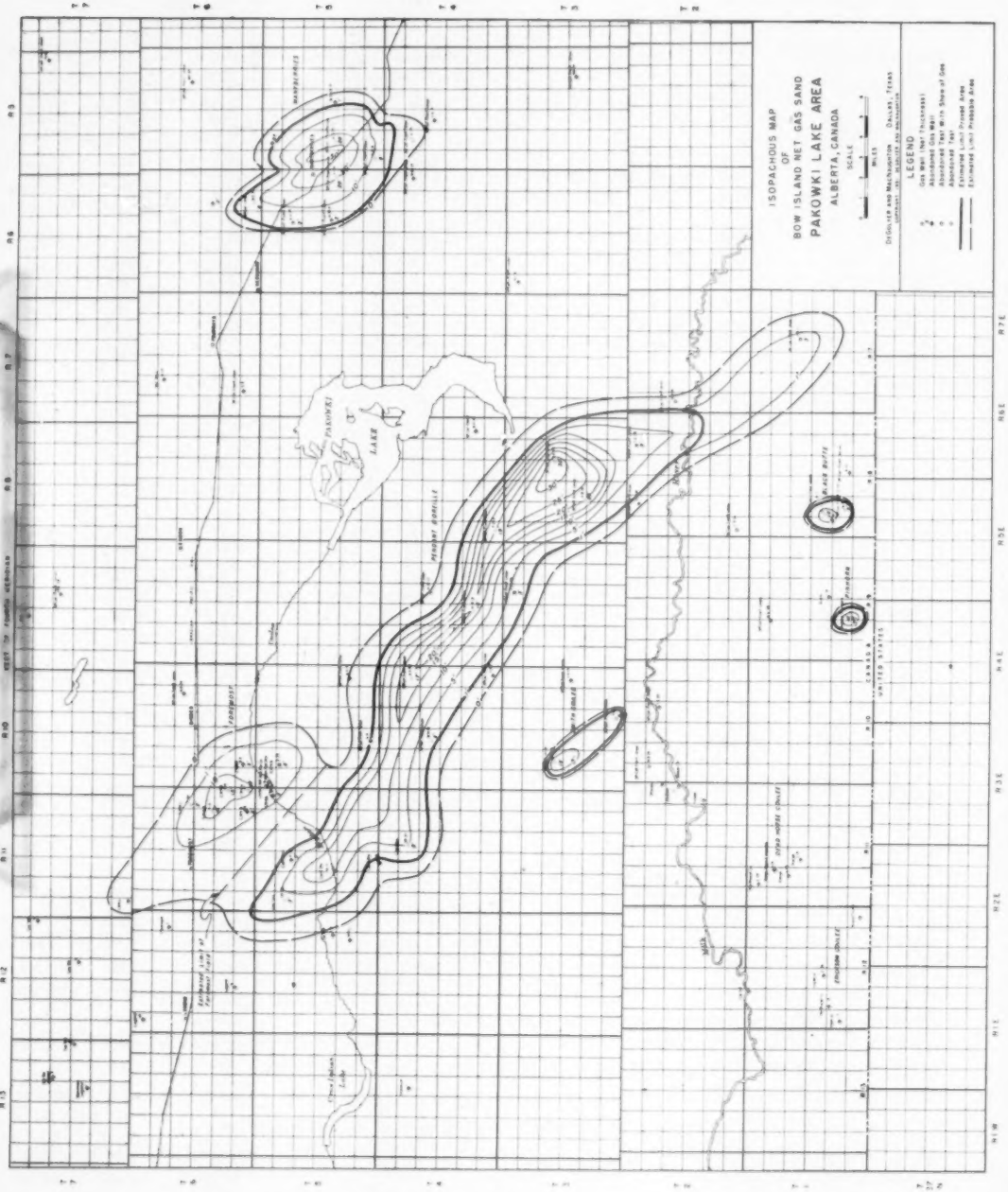

FIG. 3 — ISOPACHOUS MAP OF BOW ISLAND NET GAS SAND, PAKOWKI LAKE AREA, ALBERTA, CANADA.

productive limit of the Nisku (D_3) reservoir is defined by a permeability pinchout caused by a change of facies from dolomite to anhydrite. The largest accumulation of Devonian gas discovered in the province occurs in the Leduc (D_3) dolomite. Its gas cap has an approximate area of 14,000 acres and an average gross thickness of 65 ft. An additional large reserve of dissolved gas is contained in the oil accumulation.

Viking-Kinsella Field

The Viking-Kinsella Field is located about 80 miles east and slightly south of the city of Edmonton. This field was discovered in 1914 and produces non-associated gas from the Viking sand of Lower Cretaceous age found at an average depth of 2,100 ft. The Viking is a blanket sand, containing approximately 497,000 acres within the proved limits. Lack of permeability and/or local pinching out of the sand updip, to the east of the proved limits, results in a stratigraphic trap.

The Viking-Kinsella Field is the principal gas supply field of Northwest Utilities Limited. This company furnishes gas to the Edmonton area.

Southeastern Alberta Plains

The majority of the natural gas accumulations in the Southeastern Plains occur in Lower Cretaceous sands. The area included extends from north of the Cessford Field south to the International border, and from the Foothills Belt eastward to the Alberta-Saskatchewan boundary.

In the Southeastern Plains Lower Cretaceous rocks lie unconformably on Mississippian beds which are in turn conformable on Upper Devonian. Severe eastward truncation of Mississippian beds caused an irregular topography, and this relief is commonly several hundred feet. Deposition of Lower Cretaceous sands on this irregular Mississippian erosional surface is at times a controlling factor in the formation of Lower Cretaceous structures, modified by gentle post-Cretaceous arching along pre-Cretaceous axes of folding. This type of deposition often results in loss of porosity and permeability.

Cessford Field

Cessford Field is the third most important non-associated gas accumulation in the province. Commercial quantities of gas in the Viking, Blairmore, and Princess (Sunburst) sands of Lower Cretaceous age have been tested over an area of some 25 miles by 15 miles.

Gas accumulations in general are associated with structural closure but the dominating control is stratigraphic. Three regional northwest southeast parallel anticlinal axes, plunging northwestward, pass through the field. Local closures are separated by saddles.

The discovery well was drilled in 1949 in the Sunnynook portion of the field by Amerada Petroleum Corp. and Stanolind Oil and Gas Co. In the fall of 1950 Canadian Delhi Oil Limited and Hudson's Bay Oil Co. Limited began a drilling program south of this discovery. Subsequent development has joined these two areas of gas production and some 25 wells have been drilled, of which 15 produce gas.

The Sunnynook area offers the more favorable possibilities for commercial accumulations of gas in the Viking sand. While a few measurable flows of Viking gas have been found in the southern portion of the field, no wells have been completed, presumably due to high connate water content and low permeability. A deep structural saddle separates the Sunnynook area from the remaining portion of the field and this may have contributed to a difference in sand quality and hence a lack of commercial gas saturation in the southern portion of the field.

The principal gas reserve occurs in the Blairmore sand. Porosity pinch-outs to the east and to the west, limit the productive area. The gas-water interface is tilted upward to the southeast, in the direction of the major axis, and also rises slightly toward the porosity pinch-out at the eastern limit of the field. The gas-water interface is considerably lower in the Sunnynook area. A deep and nonproductive saddle separates the Blairmore gas production of the northern and southern portions of the field.

The Princess (Sunburst) sand occurs some 40 ft above the Paleozoic erosional surface, and structural mapping indicates increased closure on this horizon. A reasonably well defined porosity pinch-out has been established at the southern limit of the field by several nonproductive Princess sand tests. In the Sunnynook portion of the field there is no appreciable variation in porosity.

Pakowki Lake Gas Area

The Pakowki Lake area lies in the extreme southeastern portion of the province of Alberta and includes the Pendant d'Oreille, Foremost, Manyberries, Smith Coulee, Black Butte, and Pinhorn Fields. Exploratory drilling which began in 1923 has proved considerable reserves of natural gas. Isopachous maps of the fields in the Pakowki Lake area are shown in Fig. 3.

The major field of the Pakowki Lake area is Pendant d'Oreille, discovered in 1946 when McColl-Frontenac Oil Co. Limited and Union Oil Co. of California completed their Bow Island gas well. The field now contains eight gas wells which produce from five Bow Island sands. The uppermost sand contains the major gas reserve due to its greater porosity, net productive thickness, and areal extent. The gas accumulation is a typical stratigraphic trap, with the sands pinching-out or becoming low in permeability updip and containing water downdip.

Medicine Hat Field

Interest was first directed to natural gas at Medicine Hat by gas seepages in the South Saskatchewan River. Early in 1890 a bore hole was sunk in search of coal which discovered gas in the Milk River sand at a depth of approximately 700 ft. In 1908 the Canadian Pacific Railway Co. drilled a well to a depth of 1,000 ft and obtained gas from the Medicine Hat sand, which later proved to be the principal gas reservoir of the field.

The accumulation of gas in the Medicine Hat Field is dependent primarily on the variation in permeability, and structure is relatively unimportant. An area of sand with low permeability surrounds the field. Shows and small measurable volumes of gas are encountered in this area of low permeability, and it is likely that a substantial volume of gas can be drained from this area by the producing wells.

More than 100 gas wells have been completed, but there were no systematic records of early drilling or production. Since 1927, accurate records have been kept only of gas

metered for domestic use. To estimate the natural gas reserves of the field by the equal pound loss method, it was necessary to use production and pressure data for the interval from 1945 to 1950. A comparative estimate also was made by the volumetric method. Although the limited data available for calculation of reserves by either method makes it difficult to state which computation provides the better estimate, it would seem that the estimate based on the equal pound loss method is probably the more reliable.

Peace River Area

The first well to indicate the possibilities of large gas reserves in this area was drilled north of Peace River Townsite in 1916 in what is now known as the Peace River Field. Large quantities of gas were found in the Lower Cretaceous sands from depths of 335 to 1,200 ft. Subsequent to this discovery, 18 wells were drilled in the immediate area. The principal gas pay occurs in Loon River sands of Lower Cretaceous age. Seven old wells still are flowing gas and water.

During the summer of 1950 a major gas discovery was completed by Shell Oil Co. and British-American Oil Co. at Whitelaw, some 35 miles southwest of the old Peace River Field. The well was significant because it discovered the first accumulation of gas in Triassic sediments in the province. Gas was also proved in Lower Cretaceous sands. The drilling and completion of six additional wells have confirmed the occurrence of both Lower Cretaceous and Triassic gas pays over a large area.

The accumulation of gas at Whitelaw occurs in a northwest-southeast trending anticline plunging to the northwest, with the possibility of a porosity pinch-out to the northeast.

A second major discovery was made in 1951, 15 miles to the southeast of the Whitelaw Field by Hudson's Bay Oil Co. Limited and the Union Oil Co. of California in Lower Cretaceous and Triassic sands. The discovery well of the North Tangent Field blew out, but was brought under control and capped for later completion as a gas well. Four additional widely separated wells have been drilled, each of which had commercial quantities of gas in both reservoirs.

Although the field is not yet defined, present available data make it reasonable to assume that the North Tangent accumulation is similar in nature to that at Whitelaw.

POSSIBILITIES OF FUTURE GAS DISCOVERIES

Exploration for natural gas reserves in the province of Alberta has been accelerating rapidly during the past two years, primarily because of the prospect of an increased market demand resulting from the possible export of gas. The scope of this paper does not allow a complete discussion of all the gas prospects in the province, and will be limited to the more favorable areas.

Eastern Flank of Alberta Syncline

While the present density of drilling precludes any definite statement of boundary, it is apparent that a place is reached on the Alberta shelf where the rate of dip steepens into the Alberta syncline. This relatively steeper flank of the shelf area parallels the Foothills Belt from the Athabaska River south to the international border, and has a width approximating 60 to 75 miles.

The few wells drilled suggest that throughout this eastern flank of the Alberta syncline, Cretaceous sands will be thicker and better developed than on the Alberta shelf. Moreover, it is likely that at several stratigraphic levels certain sediments present in the syncline will be overlapped updip by younger sediments resulting in intraformational stratigraphic traps of Devonian, Mississippian, and Cretaceous ages.

A combination of these factors leads to the possibility that along this eastern flank of the Alberta syncline continued exploration may result in important new gas reserves. Until wells are drilled, it will not be known whether porosity and permeability will be developed suitably, but this should not condemn initial exploration. Possibly the most unfavorable factor will be in greater drilling depths.

Two discoveries late in 1951 demonstrate these possibilities on this eastern synclinal flank, namely, the gas in Devonian sediments at Neapolis (T31,R27,W4) and the gas in Cretaceous sediments at Chancellor (T25,R21,W4).

Central Alberta Plains

More than 60 per cent of the localities of measurable gas which have been found in Alberta are concentrated in the Central Alberta Plains. One-half of the 24 fields reflecting recoverable reserves in excess of 100 billion cu ft are located in this area. Included are the important associated and dissolved gas reserves of Leduc-Woodbend, Golden Spike, Acheson, and Redwater Fields, and such non-associated gas fields as Viking-Kinsella, Legal-Morinville, and Provost. The Central Alberta Plains is presently the most attractive area in Alberta in which to continue exploration. Drilling depths are generally less than 6,000 ft. Most of the Devonian reefs are confined to this area. Despite the fact that the density of drilling is greatest in this area, it ranks first in current operations. Major additions to gas reserves are continuing as evidenced by the recent discovery of associated and dissolved gas at Bonnie Glen (T47,R27,W4) and non-associated gas at Hackett (T36,R18,W4).

Throughout most of the Central Alberta Plains sediments of Cretaceous age rest on Devonian. Multiple non-associated gas pays are common in the Lower Cretaceous and gas is productive from sands, both blanket and lensing in type, characterized by local pinch-outs of porosity and permeability. Multiple oil pays are common in the Devonian and these contribute important reserves of associated and dissolved gas.

The Central Alberta Plains is usually referred to as a homocline. In a stricter sense, it is composed of many semi-parallel northwest-southeast regional folds of low relief which apparently persist for long distances. Geophysical prospecting has been successful in outlining local closures, structural terraces, and areas of reef development related to those axes. Many such prospects, when drilled, have produced oil or gas. Accordingly, this high percentage of success, even where the density of dry holes has been relatively high, suggests that the Central Alberta Plains will continue to be the most favored area for exploration.

The newest area in the Central Alberta Plains to receive attention as a gas prospect is at Lac la Biche located some 200 miles northeast of Edmonton. Two years ago several wells encountered considerable volumes of non-associated gas, less than 2,000 ft in depth, in Lower Cretaceous sands and in Devonian dolomites. The principal gas occurrence was found at 800 ft in Pelican (Viking) sand. These wells were widely separated and suggest that substantial gas accumulations exist over a large area. Mechanical difficulty in completion caused

by gas blowouts, together with their distance from a gas market, caused the wells to be capped as potential gas wells. A drilling program is now in progress, which if successful, may contribute major gas reserves.

Southeastern Alberta Plains

Gas prospecting in this area has been extremely successful in the past several years. The discovery of Cessford, Oyen, Sibbald, Countess, and other fields, has increased substantially the gas reserves of the province.

In many fields, multiple gas pays have been encountered in the Lower Cretaceous sands. These sands are blanket over the southeastern plains but manifest local pinch-outs in porosity and permeability. A maximum drilling depth of 4,000 ft makes wildcat drilling attractive. Locations for wildcats have been made frequently on seismic highs with a satisfactory success ratio.

From the Saskatchewan border to the Alberta foothills on the west, many semi-parallel northwest-southeast regional folds apparently exist which plunge to the northwest. It is along and adjacent to the axes of these folds that the greatest accumulations of gas in Lower Cretaceous sediments have been found. While the density of drilling is not great, the majority of dry holes record gas and/or oil shows in Cretaceous sands. Because of this fact, and due to local reversals of plunge, these regional axes afford one of the more favorable areas to explore for gas in the Cretaceous.

Peace River Area

Developments to date indicate the possibilities of large accumulations occurring over wide areas. Recently a well was completed at Hamelin Creek approximately 25 miles southwest of Whitelaw which gauged 66 million cu ft of gas per day on production tests from Cretaceous sands. Gas saturation also was proved in the Triassic by drillstem tests, but the gas obtained was not in commercial quantities.

Numerous successful tests have been made in Upper Cretaceous, Lower Cretaceous, Triassic, and Mississippian reservoirs within the general Peace River area. While Lower Cretaceous and Triassic sediments seem to offer the reservoirs of most promise, it is significant that in the eastern portion of the Peace River Area sediments of Mississippian, Pennsylvanian, Permian, Triassic, and Jurassic age all thin to zero under Cretaceous cover. Such a subsurface relationship produces stratigraphic traps many miles in length, and at relatively shallow depths, in which gas and oil could accumulate. Seemingly the most suitable areas for such potential accumulations would be at the updip edge of a trap where it is crossed by existing northwest-southeast regional folds.

RATE OF GAS DISCOVERY

An interesting approach to the prediction of future gas discovery in Alberta is to examine the results of past efforts. Table V lists the initially recoverable gas reserves (proved and probable) as now estimated and credited to the year of discovery together with the cumulative total for each year listed. The same material is depicted graphically in Fig. 4.

Table V — Cumulative Initial Recoverable Gas by Years for the Province of Alberta, Canada

(All Volumes Expressed at Base Pressure of 14.4 psia and 60°F)

Year (1)	Initial Recoverable Gas Found Each Year, MMcf (2)	Cumulative MMcf (3)
1890	1,127,477	1,127,477
1897	5,000	1,132,477
1909	50,066	1,182,543
1910	5,555	1,188,098
1914	1,015,217	2,203,315
1923	95,179	2,298,494
1924	2,130,055	4,428,549
1932	1,448	4,429,997
1934	8,379	4,438,376
1937	9,875	4,448,251
1939	54,693	4,502,944
1940	326,874	4,829,818
1941	48,252	4,878,070
1942	48,144	4,926,214
1943	16,056	4,942,270
1944	786,831	5,729,101
1945	42,973	5,772,074
1946	582,849	6,354,923
1947	1,892,937	8,247,860
1948	2,328,909	10,576,769
1949	1,803,689	12,380,458
1950	990,428	13,370,886

It will be noted that during the five-year period, 1946 to 1950, inclusive, more gas reserves were discovered than during the entire preceding period of 63 years. This effect will become more pronounced as development drilling progresses, permitting a better evaluation of the reserves found in recent years, particularly in 1949 and 1950. It should be appreciated that the majority of gas reserves to date have been found incidental to the search for oil. None of the major gas reserves discovered in the last five years is being marketed in appreciable volume. Of the discoveries made in the last decade, Jumping Pound is the only field from which gas is being marketed, and this outlet was not realized until 1951, seven years after its discovery.

Any reasonable extension into the future of the reserve discovery curve of Fig. 4 indicates that large volumes of gas remain to be found in Alberta. Relative exploration of the Alberta sedimentary basin is in its infancy compared with most similar basins in the United States, even though drilling activity in 1951 reached an all-time high. When an adequate market for gas is provided, it is likely that the gas reserves of Alberta will more than double during the following decade.

FUTURE AVAILABILITY OF PIPELINE GAS

Future availability might be defined as projected possible rates of gas delivery from a property, reservoir, field, or a group of fields and deliverability as rates limited by market demand or regulatory practice.

Estimation of Projected Performance of Free Gas

Procedure for estimating projected performance of free gas reservoirs may be stated simply as the application of pressure-volume-temperature relationships and the back pressure method of rating a gas well's potentiality as presented in a publication of the Texas Railroad Commission[1] and in the Bureau of Mines' Monograph 7.[2]

Prior to commencing the actual mechanics of a performance study, an estimate of the future availability of pipeline gas

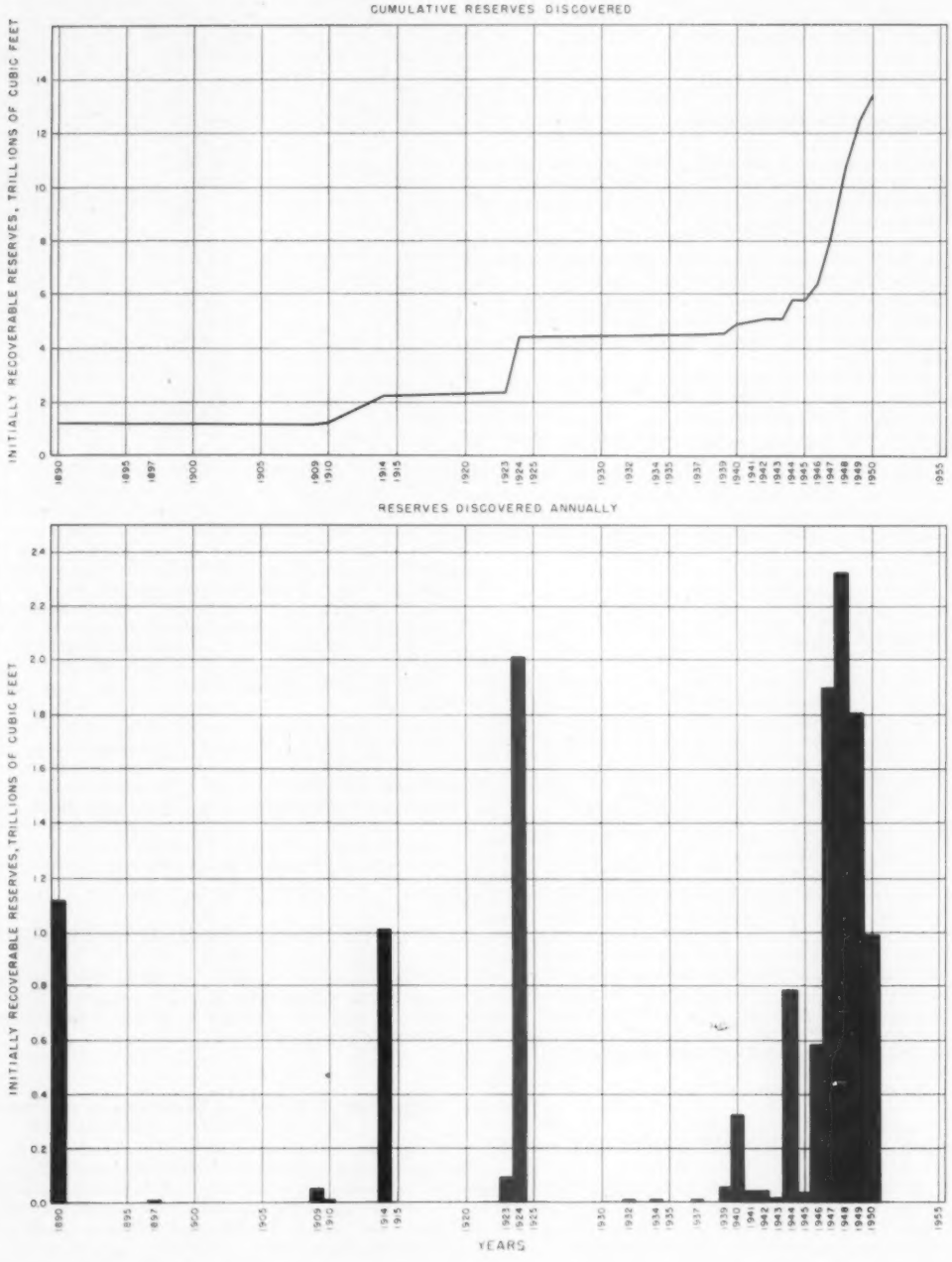

FIG. 4 — DISCOVERY RECORD OF INITIALLY RECOVERABLE GAS RESERVES (TOTAL PROVED AND PROBABLE), PROVINCE OF ALBERTA, CANADA.

from a free gas reservoir should be based on a considerable volume of detailed data including, but not limited to:

1. Initial gas in place.
2. Recoverable gas.
3. Production history, preferably at intervals to coincide with pressure determinations.
4. Initial static reservoir pressure.
5. Initial average static wellhead pressure.
6. Average static reservoir and wellhead pressures immediately prior to the date of the first projected delivery, if the reservoir has been producing.
7. An estimate of the amount of gas which will be required over the period of the study for development, field and fuel uses, shrinkage, compression fuel if required, line losses, etc.
8. An estimate as to the number of wells which will be required for final development, as well as their approximate location.
9. Limits of the reservoir and its structural configuration.
10. Open flow capacity tests, preferably back-pressure tests, on the completed wells.
11. Operating pressure of the line.
12. Term of the projection.

The expected pressure drop per unit of production must be predicted. If adequate and accurate pressure vs production data are available for a producing reservoir for which the productive limits are well established, these data should be used in predicting pressure drop per unit of production. In the ideal case, where instantaneous stabilization would be achieved and the pressure thereby equalized throughout the reservoir, the productive limits of the reservoir would not be necessary in determining the average pressure. Care should be exercised in evaluating the data to determine the effect, if any, of water encroachment. Extreme care also should be used in determining the average pressure of the reservoir. In this respect, perhaps the most accurate approach, knowing the limits of the reservoir, is to construct at various time intervals, isobaric maps superimposed on net pay isopachs to arrive at average static pressures weighted by reservoir volumes. This is particularly important early in the life of the reservoir. If the reservoir has not been produced, the pressure drop per unit of production can be estimated from the average initial pressure and the initial volume of gas in place if no water drive is expected. In most cases, sufficient accuracy results from assuming a linear relationship between pressure and cumulative production. Where data permit, deviation from the perfect gas law should be considered to improve the accuracy of the estimate.[9]

The average shut-in wellhead pressures corresponding to the weighted average reservoir pressure then can be determined. Frequently, availability studies are required on reservoirs which have experienced little or no production and generally are lacking in some of the important factual data. In such instances, it is necessary to work with the available data, known theories, and judgment.

Availability forecasts based on average wellhead shut-in and working pressures interrelated with the wellhead open flow capacity curve of the average well take into consideration both well and reservoir performance characteristics, and hence, perhaps more nearly reflect the physical deliverability to be expected from a field than forecasts based entirely on bottom-hole conditions.

Projected Performance of the Manyberries Field

A projected performance study of the Manyberries Field is presented as a typical example. This field is located on the plains of southeast Alberta approximately 95 miles east and slightly south of the city of Lethbridge and approximately 35 miles northwest of the southeast corner of the province.

The gas accumulation is found in two permeable Bow Island sands of lower Cretaceous age which are limited updip to the west either by pinching out and/or lack of permeability and are defined downdip to the east by contact with water, forming a stratigraphic trap. This field was discovered on June 26, 1947, with the completion of McColl-Frontenac-Union's well No. 7 for an estimated 30 million cu ft of gas

Table VI — Manyberries Field Estimated Natural Gas Reserves, Bow Island Sands
(All Volumes Measured at Base Pressure of 14.4 psia at 60°F)

Line (1)	Item (2)	Units (3)	Proved (4)	Probable (5)	Totals (6)
1	Type of Gas		Non-Associated	Non-Associated	
2	Specific Gravity (Air = 1)		0.59		
3	Heating Value	BTU/Cu Ft	943		
4	Estimated Productive Area	Acres	21,019	4,800	25,819
5	Estimated Average Thickness	Feet	12.0	2.0	
6	Estimated Reservoir Volumes	Acre-Ft	251,183	9,600	260,783
7	Estimated Average Porosity	Per Cent	21.2		
8	Estimated Interstitial Water	Per Cent	25.0		
9	Estimated Initial Reservoir Pressure	Psia	870		
10	Terminal Reservoir Pressure	Psia	100		
11	Estimated Reservoir Temperature	°F	85		
12	Estimated Compressibility Factor, Initial Conditions		0.87		
13	Estimated Compressibility Factor, Terminal Conditions		0.99		
14	Initial Gas in Place per Acre-Ft	Mcf	458	458	
15	Remaining Gas in Place per Acre-Ft	Mcf	46	46	
16	Total Initial Gas in Place	MMcf	115,042	4,397	119,439
17	Total Remaining Gas in Place at Terminal Pressure	MMcf	11,554	442	11,996
18	Initial Recoverable Gas to Terminal Pressure	MMcf	103,488	3,955	107,443
19	Estimated Cumulative Production to Jan. 1, 1951	MMcf	Negligible		
20	Remaining Recoverable Gas to Terminal Pressure	MMcf	103,488	3,955	107,443
21	Estimated Field and Fuel Uses	MMcf	118		118
22	Estimated Shrinkage Losses at 2 Per Cent	MMcf	2,070	79	2,149
23	Estimated Recoverable Gas Reserves (Available for Sale)	MMcf	101,300	3,876	105,176

per day through perforations from 2,519 to 2,530 ft in a Bow Island sand.

An isopachous map of net gas sand in the Manyberries Field is shown in Fig. 3. Table VI presents pertinent data and the estimated reserves of the Manyberries Field, illustrating a typical method of procedure.

Data used and assumptions made in the availability study for the Manyberries Field follow:

1. Estimated initial gas in place, 119,439 MMcf at 14.4 psia and 60°F.
2. Estimated initial recoverable pipeline gas, 105,176 MMcf.
3. Cumulative production, negiligible.
4. Initial static reservoir pressure, 870 psia.
5. Initial average static wellhead pressure, 825 psia.
6. Estimated allowance of seven per cent for field and fuel use, shrinkage, compression, etc.
7. Present number of wells, four. Estimate three additional wells to bring to final development. Therefore, the final density is 25,819 acres for seven wells, or 3,590 acres per well.
8. The four present wells have a reported total wellhead open flow capacity of 89,000 Mcf per day. The three additional completions, if well located structurally and if the sand characteristics are relatively uniform, should add approximately 80,000 Mcf per day. This would result in an overall average well equivalent to ?4,000 Mcf per day at the initial static wellhead pressure of 825 psia. It is estimated that the slope of the curve will approximate 0.85. The estimated average well curve is illustrated in Fig. 5.
9. The calculated pressure drop to production ratio is:

$$\frac{\text{Initial wellhead pressure}}{\text{Initial Gas in Place}} \quad \text{or}$$

$$\frac{825 \text{ psia}}{119{,}439 \text{ MMcf}} \quad \text{or}$$

0.0069073 lb per MMcf

10. Initial line pressure assumed at 600 psig (613 psia).
11. It was decided to determine the availability of gas from the field over a 25-year period under a reasonable development program and rate of production.

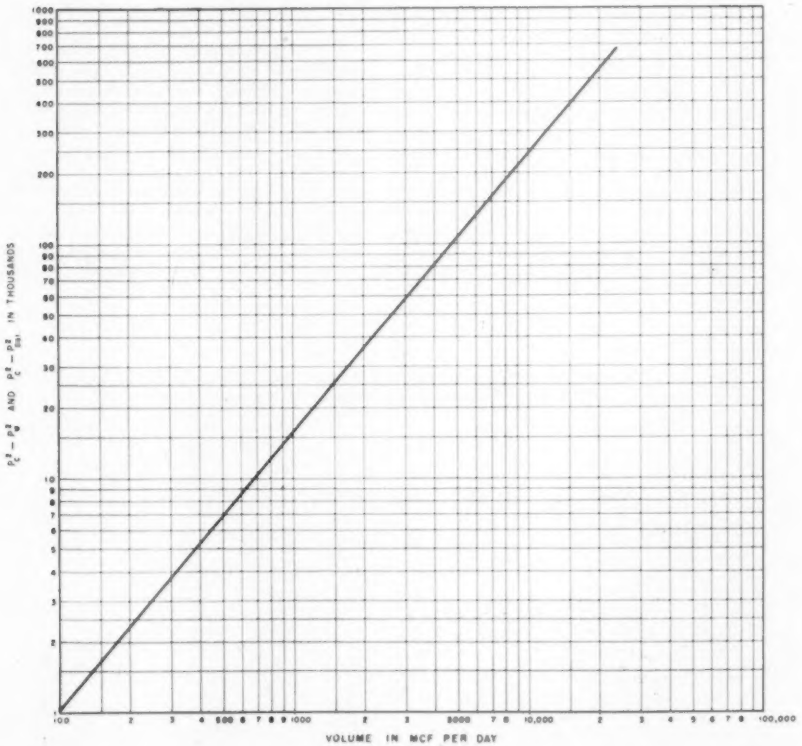

FIG. 5 — MANYBERRIES FIELD, ESTIMATED WELLHEAD OPEN FLOW CAPACITY OF AVERAGE WELL, 24,000 Mcf PER DAY AT P_c = 825 PSIA, SLOPE = .85.

The estimated average wellhead pressure at the end of each year is calculated by subtracting the product of the cumulative gross gas production in MMcf and the pressure drop to production ratio in lb per MMcf, from the initial static wellhead pressure.

By applying the square of the shut-in wellhead pressure at year-end to the curve, Fig. 5, the wellhead open-flow capacity of the average well can be determined. The total wellhead open-flow capacity is the product of the number of wells and the open-flow capacity of the average well.

From the same figure, by the application of the difference of the squares of the shut-in wellhead pressure and the line pressure, the volume of gas which the average well will produce against line pressure can be read. The number of wells times the volume of the average well is the total delivery capacity.

Table VII illustrates in detail the projected performance of the Bow Island sands in the Manyberries Field under the conditions and assumptions listed. Fig. 6 is a graphical presentation of certain of the pertinent data contained in Table VII.

Composite Future Availability

Approximately 50 detailed availability studies have been made on individual reservoirs and/or fields either singly or in groups. These studies were made for essentially all of the presently known non-associated gas reserves in the province of Alberta. In addition, availability studies were made on the substantial dissolved gas reserves of the Nisku (D_2) zone and the associated and dissolved gas reserves of the Leduc (D_3) zone in the Leduc-Woodbend Field, as well as the associated and dissolved gas reserves of the Rundle Limestone in the Turner Valley Field. From that number of studies, it was statistically possible to estimate the potential future availability of gas from the known gas reserves of the province of Alberta. The reserves used in the availability projections are as of Jan. 1, 1951, but reflect data available to Aug. 1, 1951.

Table VIII presents a composite future availability projection of gas from the currently known reserves of the province of Alberta. Availability data are presented graphically in Fig. 7. Although these illustrations present available productivity based on a practical development program and production at a reasonable fraction of open-flow capacity, actual

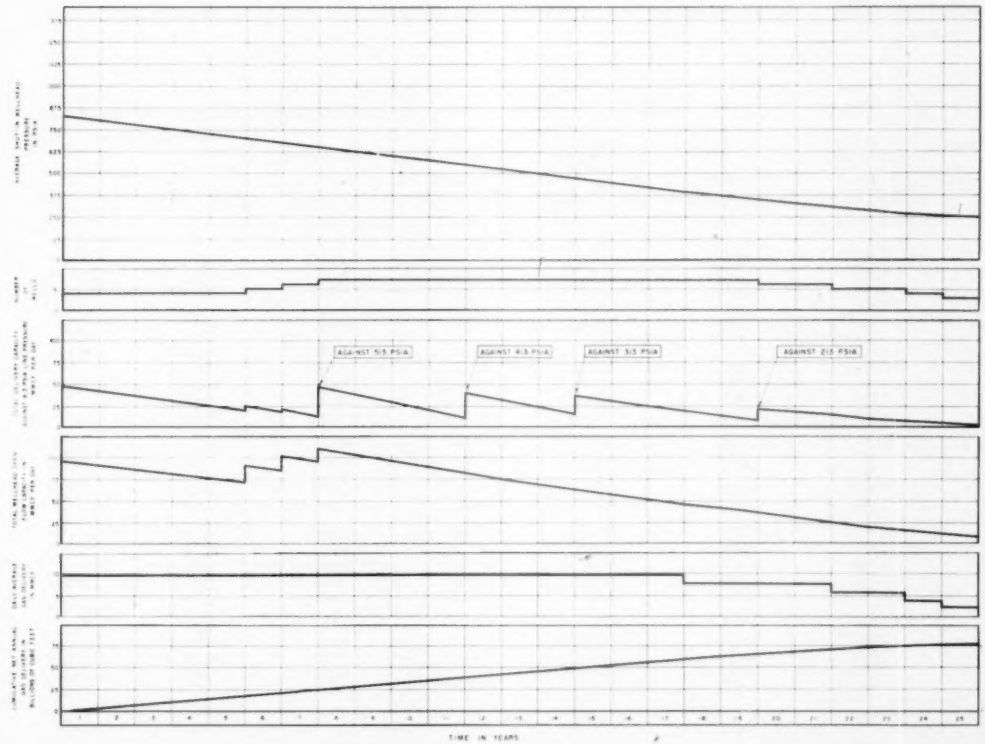

FIG. 6 — MANYBERRIES FIELD, PROJECTED PERFORMANCE — BOW ISLAND SANDS. ALL VOLUMES EXPRESSED AT BASE PRESSURE OF 14.4 PSIA AND 60°F.

deliverability will be determined by market demand, which, in turn will influence the rate of development.

It should be stressed that the composite future availability of gas which is herein presented can in no sense be viewed as a prediction of the actual amounts of natural gas which will become available from the province of Alberta during the period 1951 to 1976. The natural gas supplies in Alberta will unquestionably be increased, and substantially, by future exploration. Therefore, the volumes of gas as presented in Table VIII should be viewed as absolute minimum volumes to be expected at any certain period. In fact, recent extensions and developments since the date of the various availability studies have materially increased the supply of gas.

GAS REQUIREMENTS AND GAS SUPPLY IN ALBERTA

The natural gas requirements of the province are being served principally by two major gas utility systems: the Canadian Western Natural Gas Co., and the Northwestern Utilities Limited. The Canadian Western Natural Gas Co. supplies the Calgary area, and Northwestern Utilities Limited serves the Edmonton area. In addition, there are approximately 15 local systems furnishing gas to as many small communities.

Gas consumption in the province of Alberta has shown a substantial increase during the period from 1940 through 1950 according to The Petroleum and Natural Gas Conservation Board.[18] During 1940, a total of approximately 15 billion cu ft of gas was consumed. In 1950, the annual consumption of gas had risen to approximately 48 billion cu ft. This reflects an increase of 220 per cent. The per capita rate of gas consumption was approximately 19 Mcf in 1940 and 54 Mcf in 1950, or an increase of 184 per cent during the period.

The Petroleum and Natural Gas Conservation Board has estimated the total annual gas requirements of the province at 58.6 billion cu ft for 1952, increasing to 98.9 billion cu ft in 1960, and to 131.0 billion cu ft in 1980. The estimated requirements from 1952 to 1981 total slightly more than 3.0 trillion cu ft.

Based on the assumption that a surplus gas supply exists in the province of Alberta, at least six companies have applied to The Petroleum and Natural Gas Conservation Board for permission to remove gas or cause it to be removed from the province. Following a joint hearing held in 1950, the board published its findings in an Interim Report released in January, 1951.[19] After an exhaustive study of data presented to that time, the board concluded that it would not grant a permit to any of the applicants and recommended that the applications be continued.

During 1951, a series of hearings was held at which applicants presented new and more detailed estimates concerning provincial requirements, gas reserves, and gas deliverability. The conservation board, at the time of writing, is in the process of studying data presented in the 1951 hearings and should

Table VII — Manyberries Field,
(All Volumes Expressed at Base

Year (1)	Net Annual Gas Delivery, MMcf (2)	Cumulative Net Annual Gas Delivery, MMcf (3)	Estimated Required Annual Gross Gas Production, MMcf[a] (4)	Cumulative Gross Annual Gas Production, MMcf (5)	Daily Average Net Gas Delivery, Mcf (6)	Daily Average Gross Gas Production, Mcf (7)	Estimated No. of Wells (8)
							4
1	3,490	3,490	3,750	3,750	9,600	10,300	4
2	3,490	6,980	3,750	7,500	9,600	10,300	4
3	3,490	10,470	3,750	11,250	9,600	10,300	4
4	3,490	13,960	3,750	15,000	9,600	10,300	4
5	3,490	17,450	3,750	18,750	9,600	10,300	4
6	3,490	20,940	3,750	22,500	9,600	10,300	5
7	3,490	24,430	3,750	26,250	9,600	10,300	6
8	3,490	27,920	3,750	30,000	9,600	10,300	7
9	3,490	31,410	3,750	33,750	9,600	10,300	7
10	3,490	34,900	3,750	37,500	9,600	10,300	7
11	3,490	38,390	3,750	41,250	9,600	10,300	7
12	3,490	41,880	3,750	45,000	9,600	10,300	7
13	3,490	45,370	3,750	48,750	9,600	10,300	7
14	3,490	48,860	3,750	52,500	9,600	10,300	7
15	3,490	52,350	3,750	56,250	9,600	10,300	7
16	3,490	55,840	3,750	60,000	9,600	10,300	7
17	3,490	59,330	3,750	63,750	9,600	10,300	7
18	2,790	62,120	3,000	66,750	7,600	8,200	7
19	2,790	64,910	3,000	69,750	7,600	8,200	7
20	2,790	67,700	3,000	72,750	7,600	8,200	6
21	2,790	70,490	3,000	75,750	7,600	8,200	6
22	2,080	72,570	2,240	77,990	5,700	6,100	5
23	2,080	74,650	2,240	80,230	5,700	6,100	5
24	1,390	76,040	1,490	81,720	3,800	4,100	4
25	860	76,900	930	82,650	2,400	2,500	3
Totals (25-Year Period)	76,900		82,650				
Averages (25-Year Period)	3,076		3,306		8,400	9,100	

[a]Includes allowance of 7 per cent for field and fuel uses, shrinkage, compression, etc.
[b]Original.
[c]Reduce line pressure to 513 psia.

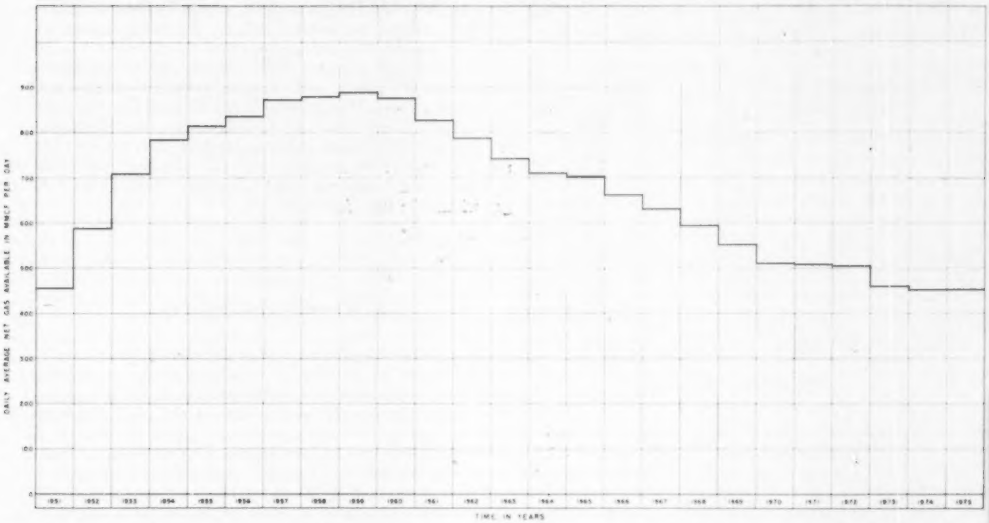

FIG. 7 — A COMPOSITE FUTURE AVAILABILITY PROJECTION FOR THE PROVINCE OF ALBERTA, CANADA. ALL VOLUMES EXPRESSED AT BASE PRESSURE OF 14.4 PSIA AND 60°F.

Projected Performance — Bow Island Sands

Pressure of 14.4 psia and 60°F)

Cumulative Pressure Drop at Year End, psi (9)	Average Shut-in Wellhead Pressure at Year End, psia (10)	Estimated Average Well Open Flow Capacity, Wellhead Conditions, at Year End, Mcf/D (11)	Estimated Total Wellhead Open Flow Capacity at Year End, Mcf/D (12)	Estimated Average Well Delivery Capacity Against 613 psia at Year End, Mcf/D (13)	Estimated Total Delivery Capacity Against 613 psia at Year End, Mcf/D (14)	Gross Daily Gas Production as a Per Cent of Total Estimated Wellhead Open Flow Capacity (15)	Per Cent Net Gas Delivered of Initial Pipe Line Gas (16)
0	825[b]	24,000	96,000	12,100	48,400		
26	799	23,000	92,000	10,800	43,200	11.2	3.3
52	773	21,500	86,000	9,300	37,200	12.0	6.6
78	747	20,100	80,400	7,900	31,600	12.8	10.0
104	721	19,100	76,400	6,400	25,600	13.5	13.3
130	695	18,000	72,000	5,000	20,000	14.3	16.6
155	670	17,000	85,000	3,600	18,000	12.1	19.9
181	644	15,700	94,200	2,100	12,600	10.9	23.2
207	618	14,700	102,900	5,500[c]	38,500	10.0	26.5
233	592	13,600	95,200	4,200	29,400	10.8	29.9
259	566	12,600	88,200	3,000	21,000	11.7	33.2
285	540	11,700	81,900	1,600	11,200	12.3	36.5
311	514	10,600	74,200	4,500[d]	31,500	13.9	39.8
377	488	9,800	68,600	3,400	23,800	15.0	43.1
363	462	8,900	62,300	2,300	16,100	16.5	46.5
389	436	8,100	56,700	4,400[e]	30,800	18.2	49.8
414	411	7,300	51,100	3,500	24,500	20.2	53.1
440	385	6,600	46,200	2,600	18,200	22.3	56.4
461	364	6,000	42,000	2,000	14,000	19.5	59.1
482	343	5,400	37,800	1,200	8,400	21.7	61.7
503	322	4,900	29,400	3,000[f]	18,000	27.9	64.4
523	302	4,400	26,400	2,500	15,000	31.1	67.0
539	286	4,000	20,000	2,000	10,000	30.5	69.0
554	271	3,600	18,000	1,600	8,000	33.9	71.0
564	261	3,400	13,600	1,400	5,600	30.1	72.3
571	254	3,300	9,900	1,200	3,600	25.3	73.1

[d]Reduce line pressure to 413 psia.
[e]Reduce line pressure to 313 psia.
[f]Reduce line pressure to 213 psia.

Table VIII — Composite Future Availability of Gas of the Province of Alberta, Canada, from Reserves as of Jan. 1, 1951

(All Volumes Expressed at Base Pressure of 14.4 psia and 60°F)

Year (1)	Estimated Daily Average Net Gas Delivery in MMcf (2)	Year (1)	Estimated Daily Average Net Gas Delivery in MMcf (2)
1951	455	1964	711
1952	588	1965	703
1953	709	1966	662
1954	782	1967	631
1955	814	1968	594
1956	836	1969	553
1957	872	1970	510
1958	879	1971	509
1959	889	1972	505
1960	875	1973	460
1961	827	1974	453
1962	789	1975	456
1963	742		
Average (1951-1976 Period)			672

present its recommendations in the spring of 1952. The petroleum industry may be assured that the findings of the board will be based on a conservative but sincere and thorough analysis of the voluminous data presented in the hearings. It appears from an engineering and geological standpoint that a substantial gas surplus exists beyond estimated provincial requirements through 1980. However, should the board not see fit at this time to recommend granting an export permit, continued exploration in Alberta undoubtedly will assure the development of a market outlet for gas within the next few years.

CONCLUSION

Recent drilling activity in the province of Alberta has resulted in a sharp increase in its natural gas reserves, bringing the estimated total recoverable volume on a proved and probable basis, as of Jan. 1, 1952, to 11.7 trillion cu ft. During the five-year period of 1946 to 1950, it is estimated that more gas reserves were discovered than during the entire preceding period of 63 years, and with the provision of an adequate market for the sale of gas, it is likely that provincial reserves will more than double in the decade to follow the realization of such market.

The present density of drilling in Alberta is about one well to 100 square miles. While measurable gas exists in every system present excepting Ordovician, a consideration of the localities capable of gas production indicates that Mississippian and Cretaceous reservoirs offer a better chance for the discovery of major non-associated gas reserves, and Devonian reservoirs for the discovery of associated and dissolved gas reserves. All of Alberta, between the Canadian Shield and the Rocky Mountain Front Range, has attractive gas possibilities and the choice of where to explore is largely a matter of an operator's preference and resources. The rate of development of one area over another may depend on its proximity to a gas pipeline should permission to export gas be granted.

A method was presented for estimating future availability of gas from a type field, and a composite estimate of the availability of gas from the province was developed. This composite future availability estimate cannot be viewed as a prediction of the actual amounts of gas which will become available. The natural gas supplies in Alberta unquestionably will be increased, and substantially, by future exploration.

At the present time no market exists for the major gas reserves discovered in recent years. Applications for permits to remove gas or cause it to be removed from the province now are pending before The Petroleum and Natural Gas Conservation Board. It appears from an engineering and geological standpoint that a substantial gas surplus exists beyond estimated provincial requirements, and that continued exploration in Alberta will assure the development of a market outlet for gas within the next few years.

ACKNOWLEDGMENTS

The authors wish to acknowledge assistance from many people, too numerous to mention individually, who contributed materially to the data used in the preparation of this paper. We acknowledge the detailed geological and well data compiled by George S. Hume and A. Ignatieff in the reports of the Geological Survey of Canada, and the "Schedules of Wells Drilled for Oil and Gas" compiled by The Petroleum and Natural Gas Conservation Board of the Province of Alberta. Special acknowledgment is made of the valuable assistance rendered by Floyd K. Beach, consultant of Calgary, Alberta, Canada, in obtaining basic geological and engineering data. We express our thanks to DeGolyer and MacNaughton for permission to publish this paper, including certain copyrighted material, and to R. B. Gilmore for his helpful suggestions in reviewing this paper. And finally, we acknowledge permission given by P. T. Bee and Frank A. Schultz, Jr., of Delhi Oil Corp. to present data contained herein.

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The Drift of Things

. . . as followed by EDWARD H. ROBIE
Secretary AIME

A Company's Stake in the AIME

At a recent meeting of the AIME Board there was considerable discussion of a suggestion that companies should be more interested in promoting AIME membership among their employes. The advocate of this idea argued that companies benefit greatly if their employes are active AIME members, so even on purely a selfish basis they should use various means to encourage membership. Also he argued that companies in general make no contribution to the support of the AIME although benefiting from its work, so should not object to making more of a contribution, financial or otherwise, than they do.

One director stated that an investigation had developed the fact that a large majority of members felt it unwise for employers to pay the initiation fees or dues of employes. They felt that AIME membership should be on a purely personal basis; that the rewards of active membership were sufficient so that it is a good investment for a man in developing his own professional stature, presumably resulting in an increase in salary sooner, or in greater amount, than would otherwise be the case. If an employer paid a member's dues or initiation fee the member would take less interest in the Institute. But this director felt that an employer should otherwise encourage his employes to join the Institute, attend its meetings, and write papers based on company work for presentation and publication. Another director reported that his company pays the expenses of AIME members in its employ to meetings; the company also encourages nonmembers to attend AIME meetings but does not pay their expenses unless they present papers of interest to the company. Another director, representing a supplier, stated that his company's policy was to send some of its staff to all AIME meetings at which papers of interest were to be presented or at which valuable contacts could be made.

The consensus seemed to be that an employer should preferably not pay the initiation fee or the dues of a member except in special cases. Such a special case might be that of a technical librarian whose company might thereby obtain technical publications at less expense than if purchased at the nonmember price. Another special case might be that of a company which wished to keep in touch with AIME activities in a certain field which might be only a fringe field for the employe for whom the membership was taken out. But companies should encourage their men to attend AIME meetings and pay their expenses thereto. They should also help Local Sections in their territory to put on good meetings. They could do this by such measures as encouraging the writing of papers; by contributing a part of the cost of dinners for Junior Members and Student Associates; by contributing transportation for a group in a company car; and by permitting and encouraging inspections of their plants on field trips, perhaps providing a luncheon for a group.

The directors of the Institute have never looked with favor on company memberships in the AIME. But they do not frown on passing the hat for voluntary contributions for special and occasional purposes, such as contributing souvenirs to an Annual Meeting; or perhaps financing a general cocktail party in preference to individual hospitality in hotel suites; or to contributions to worthy funds, such as for student prizes or scholarships, or for awards or medals.

Members of the Institute who have risen to top rank in their companies can well give thought to ways in which they can further the operation of their professional society. Their employes, as members, will benefit, as will the companies themselves.

"The People" Are of Good Will

By the time this appears in print, the Olympic Games in Helsinki (pronounced with the accent on the first syllable the Finns tell us) will have been largely forgotten, but their success affords a lesson that should be remembered. It was not the many world records that were broken. Rather it was a congress of people from all over the world that met in peaceful contest, with a spirit of good will and cordial fellowship. The hospitality of the Finns and their conduct of the meeting, with the meager resources of their little but much admired country, brought much favorable comment. But this atmosphere could not have been maintained had there been exhibitions of international and interracial enmity by the contestants. All got along beautifully with one minor exception and the fellowship between the two leading groups of contestants, the Russians and Americans, was most cordial.

The wrong people are running the world. If the athletes were put in power, or the Quakers, the ministers, the doctors, or the engineers, specially the mining engineers, we venture to say that wars would be less frequent and that people would lead happier lives. The politicians and the diplomats have a sorry record of ineptitude so far in the twentieth century. But do they ever apologize or admit their mistakes? No. They rather talk about increasing our facilities for what they euphemistically call our defense and security. Defense is too often merely another name for war; and there is no such thing as security in the measures commonly adopted to attain it.

Intelligence Test

Some of the young ladies who are compiling our Directory are being forced to learn something about geography, a subject, like grammar, so largely neglected in our schools. About a sixth of the AIME membership lives outside of the United States. Often it is a problem, never completely and successfully solved by those who work on our Directory, whether a country is independent or merely a state or province in another country. Geographical ignorance even enters the door of the Secretary's office. We read the other day that Viet-Nam is the eleventh country to ratify the UNESCO pact to remove tariffs on the importation of educational, scientific, and cultural materials. Among the other 10 countries that have ratified it are Cambodia and Laos. Now we have not the slightest idea where Viet-Nam is, nor have we any recollection of ever having heard of the country before. Our ignorance of Laos is almost equally great and we are not at all sure about Cambodia.

Negroes in Engineering

Engineering careers are being increasingly opened to Negroes. RCA-Victor has been scouting for Negro engineering talent for more than three years, has hired 16, nine of them this year, and reports that probably every reasonably qualified Negro engineering graduate has received at least one attractive offer of engineering employment in American industry. Negro engineers are practically if not entirely absent in American mining but there are a few Negro metallurgists and chemists and at least one is an AIME member. When his application was reviewed it was made known that he was a Negro but his application was unanimously approved. ★ ★ ★

Claude R. Hocott Elected 1953 Branch Chairman

Claude R. Hocott, assistant head of the production research division, Humble Oil and Refining Co. in Houston, Tex., was elected last month to the chairmanship of the Petroleum Branch, AIME, for 1953. He will take over the office from Paul R. Turnbull of La Gloria Corp., Corpus Christi, Tex., at the Annual Meeting of the Institute in Los Angeles, Calif., next February.

Announcement of Hocott's election was made at the Welcoming Luncheon of the Branch in Houston, Oct. 1. His name was placed before the Branch by the Nominating Committee last June. The committee was composed of R. W. French, chairman; H. F. Beardmore, J. C. Calhoun, Jr., H. S. Kelly and M. B. Standing.

Subsequent to this nomination, which was announced in the June issue of JOURNAL OF PETROLEUM TECHNOLOGY, a group of members placed in nomination the name of Paul Weaver of Gulf Oil Corp., Houston. This necessitated the holding of an election, and the names of the two men, along with brief biographies, were submitted to the membership on a ballot. A tally committee composed of D. V. Carter, chairman; Sam N. DeWitt, and A. S. Rhea, all of Dallas, opened and computed the ballots on Sept. 29. Total of votes received was 2,578.

Of these votes, 1,325 were for Hocott and 1,244 were for Weaver. Nine votes were unidentified and went uncounted.

The new chairman for 1953 joined Humble in June, 1937, as a research engineer. In 1942 he was appointed to his present position of assistant head of the production research division.

A native of Arkansas, Hocott was awarded the BS, MS and PhD degrees in chemical engineering at the University of Texas, where he was a member of Tau Beta Pi, Phi Lambda Upsilon and Sigma Xi. He is presently active in the American Electrochemical Society and is a member of the API Research Advisory Committee. Hocott and his wife, Edna Rae, have two daughters, Gail, 9, and Elaine, 12. He is an elder in the Church of Christ and spends his leisure hours at his hobbies of photography, fishing, hunting, flowers and music. ★ ★ ★

Transactions Index To Be Published

Publication of an index to Petroleum Transaction of the AIME was approved by the Executive Committee at its meeting in Houston this month.

The index will include all volumes of Petroleum Transactions from the beginning, and also all issues of the old PETROLEUM TECHNOLOGY and the present JOURNAL OF PETROLEUM TECHNOLOGY. It will thus include material published in these magazines which does not appear in the annual volumes. Work will begin immediately on the project, and the index is scheduled to appear about the middle of 1953.

A recent survey of the membership revealed that initial sales would be about 800 copies at $5.00 each. Of 624 members responding to a questionnaire, 32 per cent indicated that an index would be very useful to them; 59 per cent said they would use it occasionally; and 9 per cent said they would not use it. The questionnaire was sent to only half the members, and the interest expressed was considered to be representative of the entire membership.

Total cost of the project to the Branch will be about $6,000, which will be paid from the Special Projects Fund. ★ ★ ★

Petroleum Branch Holds New Membership Contest

A Petroleum Branch membership contest is now being conducted with a deadline of Dec. 31 on applications. The contest is similar to that held during the last four months of 1951, when the Branch obtained some 30 to 50 more new members than usual.

A surprise award was given the Kansas Section at the Petroleum Branch Fall Meeting in Houston this month, for having the largest percentage increase in membership during the first eight months of this year. There was no official contest held during this period. From Jan. 1 to Aug. 31, 1952, 15 new applications for Member, Associate and Junior Member were received from the Kansas Section area, for an increase of 15.3 per cent. The award, an AIME blue and gold banner for a speaker's rostrum, was presented at the Welcoming Luncheon by Jack M. Moore, Branch Membership Chairman.

During this period the Permian Basin Section obtained 39 applications for the second highest increase of 10.7 per cent. The Southwest Texas Section ranked third with 33 applications, or 10.4 per cent.

Prize for the contest currently underway will be a lantern slide or baloptican projector. All new applications for the grades of Member, Associate and Junior Member received from Sept. 1 to Dec. 31 will be included in the contest. The winning Section or Chapter will again be determined on the basis of percentage increase in membership. All applications should be sent to the Petroleum Branch office in Dallas, and must be postmarked by midnight, Dec. 31, to be counted. ★ ★ ★

Membership Cards Will Be Sent Out Along With Bills for 1953 Dues

Decision has been made to send out the 1953 membership card to AIME members along with the regular year-end bill for dues. Heretofore no membership card has been sent until payment has been received. This necessitated a second mailing and sometimes resulted in delay at peak periods or when it is impossible to identify a payment without further correspondence, as often happens when payment is made by a bank or an employing company. A saving to the Institute of possibly $1,000 should result.

The membership card will not, therefore, constitute a receipt for dues as it has in the past. Canceled checks of members will constitute a receipt. When payment is made by means whereby the member cannot be sure that his dues have been received by AIME headquarters, a receipt will be mailed, if requested. And evidence that AIME headquarters lists a member as unpaid is the nonreceipt of journals beginning with the April issues. Members are cut off the mailing list in March if their dues have not been received.

It is hoped that this new practice will meet with the approval of members and will result in prompt payment of dues. ★ ★ ★

Use of Electronic Computers

Continued from Page 19, Section 1

exists within these limits. Further, differentiating (6) with respect to V yields

$$\sum_i \frac{-(K_i-1)^2 z_i}{[(K_i-1)V-1]^2} = \frac{dF}{dV} \quad . \quad . \quad . \quad (7)$$

which shows $\frac{dF}{dV}$ to be everywhere negative. Therefore, if a root exists, F must lie above the axis to the left of the root, and below the axis to the right, as shown in the figure.

When the function F has a root near either zero or one, the derivatives of F with respect to V may be high near the root. This seriously interferes with customary interpolation and extrapolation procedures; thus, it is desirable to locate the root by a method which does not depend on derivatives of the function.

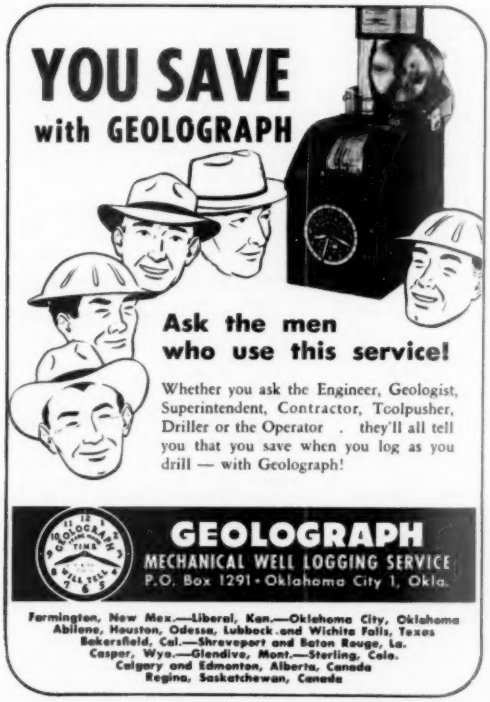
PROCEDURE

Consider the V-axis from zero to one to be divided into 2^n equal segments, $(k-1)2^{-n} \leqslant V < k \cdot 2^{-n}$, $k = 1,2, \ldots 2^n$. The single root must lie within one of these segments. The sign of $F(0.5, K_i, z_i)$ is negative if the root $V_n < 0.5$, positive if $V_n > 0.5$. There are then only 2^{n-1} segments on either side of 0.5 in which V_n may lie. If W_1 is the set of segments which contains V_n, and T_1 is the mid-point of W_1, and $F(T_1, K_i, z_i)$ is evaluated, the sign of F at T_1 determines which of the two sets of 2^{n-2} segments of W_1 contains V_n. This is defined as W_2. F is again evaluated and the sign examined as before. The process is continued for $n-1$ cycles. The value of T_{n-1} is within 2^{-n} of V_n.

This sequence of operations is easy to perform on any computer which has the capacity to evaluate the terms of Equation (6), and may conditionally alter its program as a result of a test for sign. The first trial $T_0 = 0.5$ is used to evaluate the sum of Equation (6). The sign is sensed to control the operation which gives $T_1 = T_0 \pm 2^{-2}$, the plus sign being used if F is positive. The function F is then computed from Equation (6) at T_1, from which $T_2 = T_1 \pm 2^{-3}, \ldots T_{n-1} = T_{n-2} \pm 2^{-n}$. The value T_{n-1} is then equal to V_n within 2^{-n}. This procedure has been used for computing V_n for several hundred systems with values for V_n ranging from 0.000001 to 0.999999 with good results. The work was done on an IBM 604 Electronic Calculator, which is a popular computer for accounting work and therefore, has widespread availability in the petroleum industry. The procedure is very readily programmed for this machine, and the solution is rapid. A 12-component flash may be computed to six significant figures and the results x_i, y_i, and V_n punched onto tabulating cards in 2.4 minutes. In general, for an S-component system calculated to m significant digits in V_n, the time, θ, in minutes for the punched answers, is given approximately by

$$\theta = mS/30$$

The method is quite powerful for other types of function F. The only requirements are that in the region studied the function have no discontinuities across the axis and have only one root, and that the sign of the derivative be known at the root sought. The wide latitude in permissible behavior of F, the ease of programming the iterative procedure, and the small storage requirement provide a good general-purpose method that has been found to be quite convenient in a number of practical computing applications. ★ ★ ★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Employment Notices

The JOURNAL will post notices of men and jobs available. Companies and AIME members are invited to use this space, for which there is no charge. Except as noted below, address replies to: Code (appropriate number), JOURNAL OF PETROLEUM TECHNOLOGY, 408 Trinity Universal Bldg., Dallas 1. Show return address on envelope. These replies will be forwarded unopened and no fees are involved.

Replies to the positions coded Y7572 and Y7547 below should be addressed to: Engineering Societies Personnel Service, 8 West 40th St., New York 18, N. Y. The ESPS, on whose behalf these notices are published here, collects a fee from applicants actually placed.

PERSONNEL

♦ Executive assistant, 40 years old, 20 years' experience in the drilling, production, natural gas and construction phases of the oil industry in administrative and engineering capacities. Government service with Petroleum Administration for War. Desire supervisory or advisory assignment with progressive and well established oil or gas company. Presently employed with major gas transmission company. Preferable location, Houston. Code 168.

♦ Petroleum engineer with 16 years of excellent experience in production and drilling desires a change in employment. Location in Southwest preferred. Code 171.

♦ Petroleum engineer — seven years' experience in drilling, producing and well repairs, graduate engineer, presently employed by major company. Desire responsible position with smaller company. Code 172.

♦ Geologist, 12 years' varied administrative and technical experience, advanced degrees, desire geological research position with substantial oil company in Southwest. Married, age 34. Code 173.

OIL OPERATORS AND PRODUCERS

Interested in wildcat leases and in actual or contemplated drilling operations. Will exchange cash or casing for partnership in oil-producing properties.

Code 800

Journal of Petroleum Technology

♦ Purchasing agent, expediter, 27, BBA, MBA, Columbia University, diversified experience in valves, fittings, pipe, oil drilling equipment, material. Machine shop experience, excellent factory-office liaison, knowledge of priorities, ratings. Prefer New York City. Code 174.

POSITIONS

♦ Graduate petroleum engineer with from two to five years' experience wanted for work on staff of large independent producer. Duties involve subsurface geology, development, production and reservoir engineering in California or Rocky Mountain area. Give references, details of education and experience in first letter, and enclose photograph. Code 543.

♦ General manager, under 45, chemist or chemical engineer, with about ten years' experience in the lubricating field, capable of taking complete charge of small refinery. Must be familiar with sulphurization and have some experience in fatty oils. Salary, $7,000 a year. Location, New Jersey. Y7572.

♦ Professor, preferably with PhD degree, to take charge of courses in the field of petroleum production engineering, and also do some research work along the line of reservoir engineering. Location, Southwest. Y7547. ★ ★ ★

Proposed for Membership, Petroleum Branch

Total AIME membership on May 31, 1952, was 17,772; in addition 2,413 Student Associates were enrolled.

ADMISSIONS COMMITTEE

T. D. Jones, Chairman; Thomas G. Moore, Vice-Chairman; Harold S. Bell, F. W. Hanson, R. H. Chadwick, T. W. Nelson, J. H. Scaff, John T. Sherman, A. C. Brinker, Ivan Given, C. A. R. Lambly, G. P. Lutjen, E. A. Prentis, and C. Leslie Rice, Jr.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

CALIFORNIA

Glendale — Klemme, Herbert A. (C/S-S-J).
Long Beach — Williman, Alexander O. (J); Woods, Peter G., Jr. (M).
Los Angeles — Mortado, Mohamed (R.C/S-S-J).
Oakland — Erskine, Kenneth, Jr. (J).
San Fernando — Mills, Ralph D. (J).
Solvang — Adams, John (M).

ILLINOIS

Mt. Vernon — Thompson, James W. (J).

INDIANA

Terre Haute — Jones, Robert G. R.C/S-S-J).

KANSAS

Madison — Dorris, Paul J. (C/S-S-J).
Wichita — Hofman, Hermann A. (J).

LOUISIANA

Cotton Valley — DeBord, Steve (R.C/S-J-M).
Delhi — Meek, Paul W. (R.C/S-S-J).
Harvey — Wilson, Lawrence M. (M).
Lake Charles — White, William E., Jr. (M).
Shreveport — Allen, Gordon E. (A); Kiser, John W. (M); Mahoney, Jack D. (J).

MISSISSIPPI

Lumberton — Taimortos, Paul (R.C/S-S-J).

NEW JERSEY

Montclair — Hessel, Frederick A. (M).

NEW MEXICO

Farmington — Coel, Edward J. (R.C/S-S-J).
Hobbs — Rice, John H. (J).

NEW YORK

New York — West, James A. (J).

OKLAHOMA

Duncan — Lee, Harrison B. (M).
Oklahoma City — Berryman, James E. (J).
Tulsa — Elting, William F., Jr. (M); Hampton, De Atley (C/S-S-J); Landis, Bruce A., Jr. (R.C/S-S-A); Melton, Homer D., Jr. (R.C/S-S-J); Welch, Link W., Jr. (R.C/S-S-J).

TEXAS

Abilene — Jenkins, Joseph B. (M).
Austin — Coker, Mac L. (R.M); Reed, Charles B. (M).
Bellaire — Fraser, Jack R. (A); Simpson, Harold (R.C/S-S-M).
Corpus Christi — Dueser, Frederick F. (J); Hodges, Clifford H., Jr. (J); Kullin, Robert R. (J); Mantor, Philip (M).
Dallas — Glanville, Charles R. (J); Rogers, Earl W. (R.C/S-S-J); Smith, Harold D. (A).
Fort Worth — Sears, James R. (R.C/S-S-J).
Houston — DeLaat, Bart (R.M); Sumner, Cyril R (J).
Irving — Martin, John L. (J).
Kingsville — Knigler, Kenneth A. (C/S-S-J).
Longview — DeMoss, Arthur C. (M).
Midland — Byrd, Alvis O. (M); Douglass, Fred D. (A); Ravesies, Paul (J); Warner, Frank S. (J).
San Antonio — Lap, Pieter O. (M).
Tyler — Smith, Robert F. (J); Stumpf, Clarence H., Jr (A).
Wichita Falls — Berry, Jack Frost (J).
Winters — Thompson, Richard W., Jr. (R. C/S-S-J).

CANADA

Calgary, Alta. — Pot, Robert (M).

INDIA

Digboi — Sengupta, Narayan C. (M).

MEXICO

Chihuahua — Barz, Harry R. (A).
Vera Cruz — Rice, John H. (J).

PAKISTAN

West Punjab — Dewhurst, John D. (M).

VENEZUELA

Maracaibo — Torrence, Morris W. (J). ★ ★

2nd Institute Planned On Oil and Gas Law

The Southwestern Legal Foundation at Dallas, Tex., has announced the Fourth Annual Institute on the Law of Oil and Gas and Taxation to be held Jan. 21 through 23, 1953. Continuing the policy of presenting outstanding experts in the industry, the Foundation has obtained as lecturers both lawyers and laymen eminently qualified in this field.

The institute will deal with the economics of the oil and gas industry; practical and legal problems in delay rental and shut-in royalty payments; rights and remedies for non-development and failure to off-set; federal regulation of interstate shipment and sale of gas; gas purchase contracts; rights of lessor and lessee with respect to sale of gas and as to gas royalty provisions, and the present and future prospects for natural gas.

In addition to these substantive law problems of vital interest to the oil and gas operator and his attorney, current developments on the tax scene will be discussed. Topics covered will include tax problems of re-cycling; oil income and deductions during periods of litigation; tax treatment of oil and gas interests received for services rendered; corporate distribution of earnings and profits; oil and gas taxation in Canada and current developments in taxation.

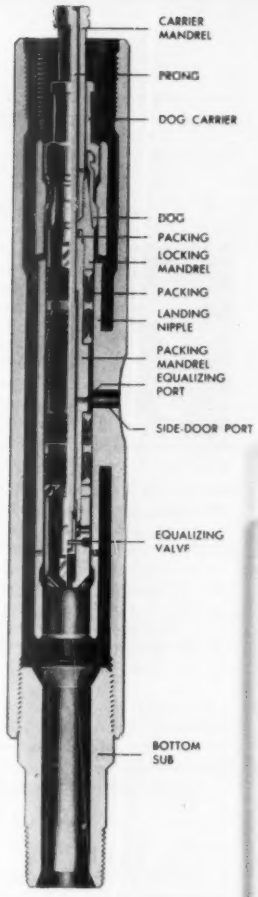
In January, 1952, over 600 oil and gas lawyers, tax specialists and executives from most of the oil producing states were in attendance at the third annual meeting. Registration fee for the three-day meeting is $35.00; single day registration, $15.00. ★ ★ ★

Gulf Coast Geologists To Meet November 6-8

Twenty papers of local and regional interest are scheduled for the second annual meeting of the Gulf Coast Association of Geological Societies, to be held in Corpus Christi, Tex., Nov. 6-8. The program includes papers on fields and formations in Texas, Louisiana and Arkansas.

The association is made up of geological societies in New Orleans, Shreveport, and Lake Charles, La.; Jackson, Miss.; and Corpus Christi, Tyler and Houston, Tex. The combined societies have a membership of about 3,000.

A bound volume, containing either the abstract or manuscript of each paper, will be available at the meeting. ★ ★ ★



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Personals

W. H. "BILL" GRIFFIN is now manager of the perforating division of Johnston Testers, Inc. at Houston. Griffin was formerly division manager in the Gulf Coast territory for Welex Jet Services, Inc., and was recently promoted to assistant to the general sales manager.

He has had long experience in the drilling and producing activities in Canada, South America and most of the oil producing states as a rotary driller, later specializing while with Baker Oil Tools, Inc., on cementing and dual completion practices. His more recent work has been in engineering, sales and service of gas lift, jet perforating and radio activity logging.

+

FREDERICK G. TICKELL, professor of petroleum engineering at Stanford University since 1921, has retired as Professor Emeritus. His office address will be Mining Building, Stanford, Calif.

+

ERNEST E. PYLES is now a vice-president of the Monterey Oil Co., successors in interest to Jergins Oil Co., located at Los Angeles, Calif.

+

D. G. KINGMAN is assistant manager of Joint Venture Operations with the General Petroleum Corp. in Los Angeles.

FRED S. REYNOLDS, formerly reservoir engineer for Humble Oil and Refining Co., at Houston, Tex., has joined the firm of Cummins and Brinkerhoff, oil and gas consultants in Fort Worth, Tex.

+

DEWITT C. VAN SICLEN is executive officer of the Office of Scientific Research, Air Research and Development Command, stationed at Towson, Md. He is scheduled for release from active duty next month.

O. U. Student Chapter Elects New Officers

The Petroleum Engineers' Club of the University of Oklahoma, an AIME student affiliate chapter, has announced election of the following officers for the current semester: Ed Prier, Oklahoma City, president; Robert F. Jones, Windyville, Mo., vice-president; Ralph Russell, Houston, secretary; William C. Osburn, Lefors, Tex., treasurer.

Standing committee chairmen elected are Burt Griffith, Winfield, Kans., St. Pat representative; Jim C. Evans, Norman, Okla., and Bob Berger, Atchison, Kans., float committee; Bob Laidlaw, Calgary, and R. J. Funk, Amarillo, Tex., open house committee, and Charles Bare, Chickasha, Okla., publicity and entertainment. ★ ★ ★

W. W. GOODE has been named assistant to the Mid-Continent area manager for Schlumberger Well Surveying Corp., with offices in Tulsa, Okla. Goode has been with Schlumberger since 1946, and served in the New Iberia and Houma, La., districts. He was most recently division manager of the Louisiana Coast division at Lafayette. He holds an MA degree from the University of Alabama.

+

HERBERT D. THORNTON has been appointed general superintendent for McElroy Ranch Co.'s newly opened Rocky Mountain office in Denver, Colo. Thornton is a graduate of the Colorado School of Mines.

W. M. Nielsen Receives Canadian Scholarship

Wilbert M. Nielsen, senior student from Calgary, Alberta, Canada, is the first winner of the newly established $750 Socony-Vacuum Canadian scholarship in petroleum engineering at the University of Oklahoma.

The award is the first at O. U. for foreign students financed by the subsidiary or affiliate of a U. S. concern. In addition to the Canadian scholarship, Socony-Vacuum has established grants in petroleum engineering and the explorative sciences at O. U. for American students.

Nielsen will receive a BS degree in petroleum engineering next June.

An outstanding student with a "B" plus grade average, he received the Board of Governors' Silver Medal for highest general standing presented by Mt. Royal College, Calgary, in 1951.

Active in student affairs, he is a member of the Petroleum Engineers' Club and the Engineers' Club.

Preference for the scholarship is given to a student of petroleum engineering, officials explained, but in the absence of a suitable candidate, the award may go to students in other fields of petroleum production activities at the University of Oklahoma. ★

ADVANCE AIME MEETING CALENDAR

	1952	*1953*	*1954*
Petroleum Branch Fall Meeting (Mid-Continent)		Oct. 7-9, Baker, Adolphus Hotels, Dallas	Not Determined
Petroleum Branch Fall Meeting (West Coast)	Oct. 23-24, Statler Hotel, Los Angeles	Oct. 22-23, Statler Hotel, Los Angeles	Not Determined
AIME Annual Meeting	———	Feb. 15-19, Statler Hotel, Los Angeles	Feb. 14-18, Statler Hotel, New York
AIME Fall Meeting		El Paso	———

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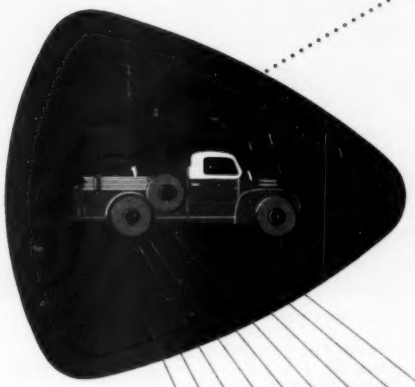

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Book Reviews

The following books are available in the Engineering Societies Library, and may be borrowed by mail by AIME members for a small handling charge. The library also prepares bibliographies and translations, and provides search, photostat and microfilm services. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

Petroleum Geology

By E. N. Tiratso. McGraw-Hill Book Co, New York, 1952. 449 pp., tables, illus., charts, maps, diag., 9½ x 6½ in., bound. $7.50.

This text covers both the academic questions related to the origin, migration, and accumulation of petroleum in the subsurface, and the practical problems of discovering and exploiting oil deposits. The latter include surface methods such as geological mapping, aerial surveys, and the evaluation of oil seepages, and also subsurface (geophysical) methods. The world's oil fields are reviewed, particularly with reference to their structural and stratigraphic history. The latest techniques of exploitation, including well-logging, are described, and there is a special chapter on drilling fluids.

Management Controls in Industrial Research Organizations

By Robert N. Anthony assisted by John S. Day. Harvard University, Graduate School of Business Administration, Boston, Mass., 1952. 537 pp., tables, 8½ x 5¾ in., bound. $6.75.

Detailed results are presented of a broad, first-hand study of the problems of administrative control of scientific research activities in American industry. Its four parts include a statement of the problem, the variable factors relating to it, current control practices, and case studies of control techniques in four specific laboratories of different sizes and kinds. Selected operating data for laboratories of different sizes and types of work are included in an appendix.

Petroleum Measurement Manual

Institute of Petroleum, London, 1952. 227 pp., diag., tables, 9¼ x 6¼ in., bound. 30s.

An authoritative and comprehensive set of instructions and recommendations for all steps involved in measuring and calculating quantities of petroleum. Equipment and procedures are treated in detail, and the book is arranged to be usable in countries using the metric system as well as in Great Britain and the United States. The six major sections are as follows: tank calibration; oil gauging; sampling for quantitive purposes; temperature measurement; specific gravity and density measurement; calculation of oil quantities. During the preparation of the book close contact has been maintained with the ASTM Committee on Petroleum Products and Lubricants.

★ ★ ★

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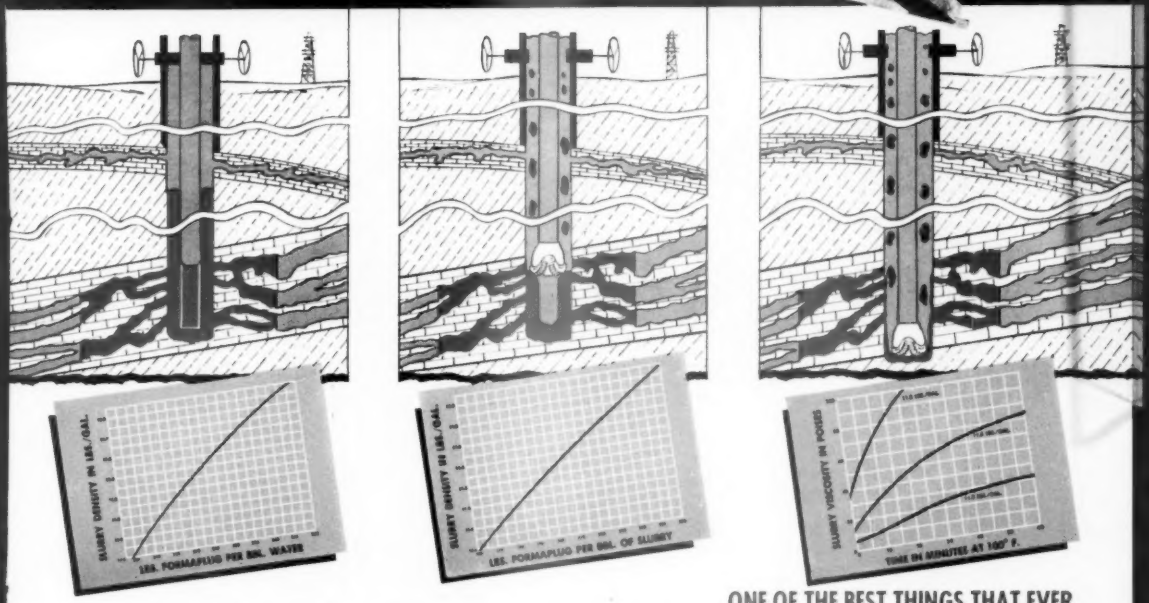
ANNOUNCING FORMAPLUG

another outstanding LOST CIRCULATION CORRECTIVE from MAGCOBAR


SLURRY DENSITY IN LBS./GAL.
LBS. FORMAPLUG PER BBL. WATER
SLURRY DENSITY IN LBS./GAL.
LBS. FORMAPLUG PER BBL. OF SLURRY
SLURRY VISCOSITY IN POISES
TIME IN MINUTES AT 100° F.

FormAplug seals cracks, fissures, solution channels, and other relatively large cavernous types of formation openings. It permanently plugs openings — doesn't merely plaster them over with a temporary mat. FormAplug stabilizes weak formations which might rupture with the hydrostatic pressure of heavy mud.

FormAplug is a time setting clay cement which is squeezed into formation fractures with ordinary cementing equipment. After a short time the slurry thickens to a rubbery solid, having a gel strength equivalent to 40,000 Stormer grams, which is capable of withstanding considerable pressure differential without movement.

The above diagrams show FormAplug being squeezed into a formation channel. Following placement of the slurry, the drill pipe is removed. After waiting a period for the FormAplug to develop strength, the FormAplug remaining in the hole is drilled out.

You will want to know more about the advantages of FormAplug. Write today for a descriptive bulletin.

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ONE OF THE DRESSER INDUSTRIES

ONE OF THE BEST THINGS THAT EVER HAPPENED TO THE OIL INDUSTRY

Magcobar
Complete
DRILLING MUD SERVICE
DEALER

MAGCOBAR, MAGCOGEL, HIGH YIELD XACT CLAY, SALT GEL, MY-LO-GEL, MY-LO-JEL PRESERVATIVE, DRISCOSE, FORMAPLUG, CELL-O-SEAL, FIBER SEAL, MAGCO FIBER, LEATHER-FLOC, MAGCO MICA, JEL-OIL MUD, JEL-OIL "B", "E" CONCENTRATE, NOHEEV, TANNATHIN, RED OX LIQUID, ALKATAN, QUEBRACHO, KEMBREAK, MAGCOPHOS, CHEMICALS.

United's Research Division, which is responsible for fundamental research and development of United's advanced equipment, has these objectives:

Making the best use of existing equipment and methods.

Improving existing equipment and methods.

Conducting fundamental studies which will improve the interpretation of data obtained by current methods.

Developing fundamentally new techniques and methods for geophysical exploration.

Advanced research is one of the reasons UNITED has been able to contribute so many outstanding achievements in geophysical exploration.

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UNITED
Geophysical Company

Herbert Hoover Jr., Pres.